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Facial Information as a Minimal Cue of Animacy

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Psychology

by

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March 2018

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March 2018

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To my parents, Elliot and Francis

and my sister, Nicole

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Teaching Experience

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Instructor of Record **Summer 2017**
Department of Psychological and Brain Sciences, University of California, Santa Barbara
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University of California, Santa Barbara, Koegel Autism Center

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Publications

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ABSTRACT

Facial Information as a Minimal Cue of Animacy

By

Erin J. Horowitz

The tendency for humans to give preferential attention to animate agents in their immediate surroundings has been well-documented and likely reflects an evolved specialization to a persistent adaptive problem. In uncertain or ambiguous cases, this tendency can result in an over-detection of animacy, as the potential costs of failing to detect an animate agent far outweigh those of mistaken identification. In line with this, it seems likely that humans have evolved a sensitivity to specific cues which are indicative of animacy such that the mere presence of these cues will lead to detection, regardless of the objective category membership of the entity in question. There exists a wealth of research speaking to this effect with regards to motion cues, specifically in terms of the capacity for self-propulsion and goal-directed action. Morphological cues have also been implicated - most especially the presence of facial features – as they specify a capacity for perceptual feedback from the environment, which is essential for goal-directed motion. However, it remains an

open question as to whether the capacity for animacy detection is similarly sensitive to facial information in the absence of motion cues.

The experiments reported here attempted to address this question by implementing a novel task in which participants were asked to judge the animacy or inanimacy (or membership in animal or object categories) of different images: animals with and without visible facial features, and objects with and without visible facial features. Beyond replicating a general advantage for detecting animate agents over inanimate objects, the primary predictions for these experiments were that facial features would have a differential effect on performance, such that they would improve performance when visible in animals, and would hinder performance when visible in objects. Experiments 1a and 1b provided a preliminary confirmation of this pattern of responses using images of familiar and unfamiliar animals (e.g., dogs versus jellyfish), and unaltered images of objects with and without faces. Experiment 2 improved on the design of this task by more closely matching the sets of images (the same animals facing toward or away from the camera, and objects with faces which had been digitally altered to disrupt the facial features), and by changing the prompt of the task from yes/no judgments of animacy to categorization into animal or object groups. Experiment 3 examined the face inversion effect, or the failure to recognize familiar faces when their orientation is inverted, on animal-object categorization. Lastly, experiments 4 and 5 attempted to extend the findings from experiment 2 to preschool-aged children, by implementing a card sorting task (experiment 4) and a computerized animal detection task (experiment 5). The results of this series of experiments highlight the prominent role of facial features in detecting animate agents in one's surroundings.

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CHAPTER 1

How and why the mind makes the animate-inanimate distinction

1. Introduction

The very nature of the world around us sets the stage for a fundamental problem which our minds must solve: in any given moment, what features of our environment should we attend to? That we should prioritize attention to certain things over others is not a controversial idea; the world around us is full of information, and it is computationally impossible for our minds to process all of it at once. At the very least, we are equipped with sensory systems which enable us to perceive distinct features and bounded entities in our surroundings. But beyond merely identifying entities as separate from one another, in order to prioritize our attention we must imbue these entities with *meaning*, as without specifying some sort of relevance for ourselves everything would exist on an equal playing field. In addition to basic perceptual systems, then, the mind must engage in at least two other broad processes: dividing the world into relevant units of meaning, or *concepts*, and employing a set of rules to determine which of these concepts to attend to in a given moment.

Psychologists typically speak about conceptual development in terms of the degree and nature of the structure present at birth. Early theories purported that the infant mind is essentially a "blank slate," equipped with basic perceptual abilities and general-purpose learning mechanisms which together enable the formation of associations between behaviors and outcomes. On the other side of the debate are those who advocate for the early existence of core domains of knowledge, which provide a skeletal framework that shapes how we learn about and interact with the world throughout the lifespan. Strong empiricism has fallen out of

favor in the last few decades, owing to a growing body of evidence demonstrating the early existence of inferential abilities in domains such as physics (e.g., Spelke, 1990), biology (e.g., Springer & Keil, 1989), numerosity (e.g., Starkey, Spelke, & Gelman, 1990), and psychology (e.g., Baron-Cohen et al., 1995; Leslie, 1994).

Core domains are thought to embody areas of knowledge that were relevant over the course of our evolutionary history. That is, they represent functional solutions to adaptive problems that were reliably encountered in our ancestral past (Cosmides & Tooby, 1994a). Solutions to adaptive problems resulted in an increase in fitness (i.e., chance of survival and reproduction), and were thus more likely to propagate forward to the next generation. To the extent that these solutions have propagated forward to modern times, they have done so in the form of functionally specialized mechanisms, which are thought to form the basis for further conceptual development.

Once a mind is able to divide the world into conceptual categories, it can start making decisions about where to prioritize attention. Those who adopt an evolutionary framework posit that decision-making processes reflect evolved specializations as well (Cosmides & Tooby, 1994b). In their most general form, such processes consider evolutionarily relevant input (computed as output from other specialized domains) to produce behaviors that had a high probability of maximizing fitness. In terms of prioritizing attention, this could manifest as an orienting to situation-specific stimuli in light of a given goal. Simply put, if we wish to accomplish something, we will look for things in our surroundings that are more likely to help us toward that end.

In the face of uncertainty, decision-making becomes considerably less straightforward. One possible explanation for how the mind may have evolved cognitive

biases for making judgments under uncertainty is known as Error Management Theory (Haselton & Buss, 2000). In applying the principles of signal detection theory (Green & Swets, 1966), the authors describe four possible outcomes for a given judgment. One can adopt a belief when it is actually true (a true positive), reject a belief when it is actually false (a true negative), or commit one of two possible errors: adopting a belief when it is not actually true (a false positive), and rejecting a belief when it is actually true (a false negative). Under error management theory, for situations in which there exists an asymmetrical fitness cost between the two errors, one should always select the error with the lower cost. If this asymmetry persists across evolutionary time, selection will favor mechanisms that are biased towards committing the least costly error.

The primary aim of my dissertation is to examine how the mind prioritizes attention to one specific type of entity: animate agents, which I will define as biological entities whose behaviors can be interpreted in terms of intentional states such as goals and desires. Animacy detection is thought to comprise a functionally specialized system, which provides the foundation for processes such as predator detection and the identification of potential cooperative partners. In this chapter, I will discuss the basic properties of this ability by first addressing how the mind uses specific cues to differentiate animate agents from inanimate objects. From there I will discuss the apparently hypersensitive nature of animacy detection in response to these cues, and why our tendency to over-attribute animacy may actually reflect an adaptive decision-making bias. I will end this chapter by briefly describing the series of experiments included in this dissertation, which attempt to assess the degree to which one cue of animacy – the presence of facial features – influences both judgments of animacy and superordinate-level (i.e., animal-object) categorization abilities.

1.2 Making Sense of the World: The animate-inanimate distinction

The observable world is made up of physical objects, which can arguably be divided into two broad classes of entities – inanimates and animates. Our intuitions about inanimate objects are constrained by the principles of Newtonian mechanics (e.g., Spelke, 1990): cohesion (objects move as bounded wholes), continuity (objects move along a continuous pathway), solidity (solid objects do not pass through one another), and contact (objects do not interact at a distance). Animate entities, on the other hand, are able to move without first being contacted, which renders their trajectory of motion considerably less predictable (e.g., Spelke, Phillips, & Woodward, 1995). This seemingly minor difference ultimately directs the inferences we are able to make about either class of entity: If we see a boulder tumbling down a hill, aimed directly for the spot we're standing in, we can reasonably assume that it is not going to suddenly veer off course, and we can choose simply to remove ourselves from its path of motion. Alternatively, if we see a bear running down a hill, aimed directly for the spot we're standing in, it is not clear that simply moving out of its way will prevent it from approaching us. Without any other information, we cannot predict its trajectory of motion, and the space of inferences we can make about it suddenly becomes too large to contemplate – and act on – in a reasonable amount of time. In a situation such as this, which inferences should the mind prioritize?

Though animate entities do not always adhere to the principle of contact, they still provide us with information that can help constrain the set of inferences we can make about them. Gelman (1990) has argued that the foundation of the animate-inanimate distinction stems from an ability to distinguish between the different "sources of energy" that drive motion (for a detailed account of the mechanical motion of animate agents see Leslie, 1994).

Inanimate entities move via a transfer of energy from one entity to another, in a causal chain of events that is objectively observable and reliable to the point that people are able to infer a causal chain of motion from static images (Michotte, 1963). Animate entities, on the other hand, move via an internal source of chemical energy which must be continually taken in from the outside world to be maintained; they are constrained by this basic function, which itself is driven by a larger biological motivation for survival and reproduction (Gelman, 1990). As such, we can attribute at least two causes of motion to animate agents – they will approach things that can confer a benefit, and will avoid things that can impose a cost. These behaviors, which are variously referred to in the literature as animate (e.g., Gelman, Durgin, & Kaufman, 1995), goal-directed (e.g., Csibra, 2008), or intentional (e.g., Dasser et al., 1989), constitute the most basic inferences that we can apply to animate entities but do not extend to inanimate objects.

Research suggests that our minds use self-propelled motion as a reliable cue of animacy. In a landmark study, Heider and Simmel (1944) asked adult participants to describe a film in which several shapes were shown moving around. Remarkably, the vast majority of participants constructed a social narrative for the shapes; their motions were described in terms of goals and desires, rather than simple physical movements. These results, which have since been replicated in a variety of different circumstances (for a review see Blakemore & Decety, 2001), suggested that animacy could be perceived from simple motion cues, even when the entities in question in no way resemble ecologically relevant animate agents.

1.3 Morphological cues of animacy indicate the capacity for self-propulsion

Thus far I have highlighted self-propelled motion as a defining feature of animate agents. But given that animate agents are not always in motion, what other cues might the

mind use to identify them? It seems likely that the most relevant features would be those that *suggest* the capacity for self-propelled motion. This would include features such as the presence of limbs (Rakison & Butterworth, 1998), or curvilinear contour (Smith & Heise, 1992), both of which indicate the capacity for locomotion. Stronger cues are likely to include features that provide more information about an animate agent's eventual goals, as such features would enable a greater degree of accuracy in predicting its likely path of motion. In pursuit of their goals, agents must necessarily interact with the surrounding environment. Perceptual abilities can provide substantial feedback to the agent, which in turn can enable it to revise its path of motion as obstacles arise. In the absence of self-propelled motion, it is likely that the presence of morphological features involved in perception can act as an equally powerful cue of animacy.

One likely candidate is the presence of facial features, as they contain a great deal of perceptual organs which enable the gathering of information from one's surroundings (eyes at minimum, but this may also include a nose, mouth, and ears). The propensity to attend to faces appears shortly after birth (e.g., Morton & Johnson, 1991), and remains present throughout the lifespan (for a comprehensive review see Palermo & Rhodes, 2007). The propensity for attending to faces is likely driven by the presence of eyes. Light has constituted an astoundingly stable selection pressure, so much so that eyes in various forms are believed to have evolved at least forty separate times across evolutionary history (Salvini-Plawen & Mayr, 1977), and are thus highly correlated with animate agents. The possession of a visual system not only facilitates the perception of objects and terrain in one's immediate surroundings, but also enables action at a distance, as being able to see allows one to identify targets to approach or avoid in a much wider radius. Because of this, attending to where an

agent is looking can help determine its likely next course of action. Indeed, humans frequently use eye gaze to infer an agent's goals and desires (e.g., Phillips, Baron-Cohen, & Rutter, 1992).

1.4 Over-detection of animacy can minimize costly errors

The animate monitoring hypothesis was first proposed by New, Cosmides, and Tooby (2007) to describe an adaptive propensity to monitor our surroundings for and attend to animate agents over and above other stationary objects. They argued that this propensity should occur as an automatic reorienting of visual attention to animate entities – outside of the control of executive functions, and without regard to the relevance of the task at hand. Empirical work supports the existence of this ability, indicating, for example, that animals are detected quickly in rapidly flashing visual scenes (Thorpe, Fize, & Marlot, 1996), even when displayed in the far periphery (Thorpe et al., 2001). Studies employing change detection paradigms have also demonstrated an advantage for detecting animate agents (humans and animals) in both adults and typically developing children (New et al., 2007; New et al., 2010).

Beyond the rapid detection of animate agents in our surroundings, the animate monitoring hypothesis predicts that we should also be quicker to identify animates that constituted consistent threats over the course of evolutionary history compared to evolutionarily novel, but equally threatening, entities. Indeed, prior research has demonstrated this for snakes (e.g., Öhman & Mineka, 2003; Gomes et al., 2017) and spiders (e.g., Rakison & Derringer, 2008; New & German, 2015). Beyond detecting animals that posed ancestrally relevant threats, humans also demonstrate an advantage for quickly detecting emotions that might indicate danger, including faces and body postures exhibiting

fear (Stein et al., 2014; Yang, Zald, & Blake, 2007) or anger (Zhan, Hortensuis, & De Gelder, 2015). Not only do we appear to be equipped for detecting specific threatening entities, but we can also detect threatening situations that deal specifically with interpersonal relationships.

The apparent advantage for detecting animate agents likely stems from error management theory, which asserts that whenever there is an asymmetric cost in errors (false positives or false negatives) to choose the one with the lower fitness cost (Haselton & Buss, 2000). What might this look like in the case of animacy detection? The system would likely be biased toward making false positives (mistakenly detecting an animate agent) rather than false negatives (failing to identify an animate agent), as the cost of the latter could potentially far outweigh the former.

As I have attempted to argue in previous sections, it appears that natural selection has provided humans with an ability to differentiate animates from inanimates, and, more importantly, to bias this ability toward quick rather than accurate detection of animate agents. Building off of similar research on motion cues, the experiments described in the chapters to follow explored the influence of facial features in the animate-inanimate distinction. Over and above a demonstration of the so-called "animate advantage", we wanted to show that, when making judgments based solely on static cues, the presence of facial features can speed judgments of animacy for animals, and can slow judgments of animacy when detected "out of context" – as features in inanimate objects. Pareidolia, or the tendency to see faces in objects (e.g., Guthrie, 1993), is a common phenomenon which speaks to the sensitivity of face detectors. The tendency to detect faces in entities that are blatantly not animate – and that people will consciously tell you are not animate – affords an interesting opportunity to

examine the extent to which facial features can influence initial judgments of animacy. Although people may ultimately make correct judgments when it comes to sorting the world into animate and inanimate entities, the presence of a face – even in an obviously inappropriate context – may give them pause, which may hint at the suppression of a default response. It is this phenomenon that we wish to exploit in this series of studies.

The experiments described here (with the exception of experiment 4) implemented a timed computerized task during which participants viewed a series of images and were required to make quick judgments regarding their animacy or inanimacy, or their membership in the animal or object category. Across all of these experiments we used four categories of images: animals with visible facial features, animals without visible facial features, objects with visible facial features, and objects without visible facial features.

Five experiments will be discussed here. In experiments 1a and 1b (Chapter 2), we introduce a novel paradigm, the goal of which is to measure the influence of facial features when judging the animacy (exp. 1a) or inanimacy (exp. 1b) of animals or objects. This set of experiments was meant to act as a proof of concept, first by replicating the so-called "animate advantage" (e.g., New et al., 2007), and then by demonstrating that animals with visible facial features will be identified faster than those without, while objects with visible facial features will be identified slower. In this first set of experiments, we used unaltered images of animals with faces (e.g., dogs, cats), images of animals without faces (e.g., insects, sea creatures), images of objects with apparent facial features, and an unmatched set of images of objects without facial features.

In experiment 2 (Chapter 2) we implemented this same task, but with more well-controlled image sets that were matched for both animals (images of the same animal facing

toward and away from the viewer) and objects (images of the same objects with faces, but digitally altered to disrupt configural processing for the "no face" condition). The prompt was also changed from an abstract yes/no judgment of animacy/inanimacy to a more concrete categorization into objects and animals. In making this change, we hoped to remove any existing endorsement bias (i.e., a propensity to favor "yes" responses; e.g., Knowles & Condon, 1999), and to remove any possible ambiguity in participants' definitions for "animate" and "inanimate."

In experiment 3 (Chapter 3), we examined the inversion effect on animal-object categorization. Prior studies have demonstrated that inversion disrupts the ability to recognize familiar faces (e.g., Yin, 1969), but there is conflicting evidence as to whether this effect extends to the ability to *detect* faces. We propose that examining the inversion effect as it pertains to animacy detection may provide insight into how the mind detects faces, as this system is purportedly hypersensitive to cues of animacy, and thus might allow for a certain degree of variance in orientation. We reasoned that if objects with faces are equally difficult to correctly categorize when inverted, this system must still be processing them as faces. If, on the other hand, the set of inverted objects is easier to categorize, it suggests that input to the animacy detection system is constrained by orientation, and implies that inverted faces may not be detected as such.

Finally, experiments 4 and 5 (Chapter 4) examined the influence of facial features on categorization in preschool-aged children, at an age when they are purportedly just attaining mastery at animal-object categorization, but still demonstrate marked over-generalizations of animacy to entities that exhibit self-propelled motion. Experiment 4 presented a sorting task, in which we asked children to sort images into animal and object boxes. We proposed that

facial features may have a similar effect as self-propelled motion in this age group, and would result in children making more errors when asked to correctly categorize objects with faces and animals without faces. In experiment 5, we implemented a computerized task modeled after the animacy categorization task (exp. 2-3) in which we displayed two images, side-by-side, and asked children to "catch the animal" as quickly as possible. Here we reasoned that children would have more difficulty correctly responding to cases in which animals with faces were paired with objects with faces, and, to a lesser extent, when animals without faces were paired with objects with faces.

CHAPTER 2

Facial features can act as a reliable cue of animacy in the absence of motion

1. Introduction

On a daily basis, and over the course of evolutionary history, humans have been motivated to interact with other animate agents in their surrounding environment. There likely exists an adaptive advantage for selectively detecting and attending to animates, as they present opportunities for a wide variety of social interactions (New, Cosmides, & Tooby, 2007). The preference for attending to animates emerges early in life (for a review see Opfer & Gelman, 2011), and animacy detection from minimal cues appears to be present across a wide range of cultures (e.g., Barrett, Todd, Miller, & Blythe, 2005). When examining animacy detection in adults, animates are more quickly identified (New et al., 2007), are more easily recalled from pictures and word lists (Bonin, Gelin, & Bugaiska, 2014), and form stronger associations to novel words (Nairne, Vanarsdall, & Cogdill, 2017), compared to inanimate objects. Although this robust tendency to attend to animate agents in the environment is well-documented, the mechanisms that underlie this ability deserve a much closer look.

An important area of inquiry concerns the specific environmental cues that allow the mind to make attributions of animacy. One key feature that differentiates animate agents from inanimate objects is self-propelled motion (Leslie, 1994; Premack, 1990). Infants demonstrate a preference for looking at objects that appear to move on their own, compared to objects that move after coming into contact with another object (Di Giorgio, Lunghi, Simion, & Vallortigara, 2016), and they associate self-propelled motion with animacy and mechanical motion with inanimacy (e.g., Markson & Spelke, 2006). In adults, a myriad of studies has demonstrated the tendency to over-attribute animacy to inanimate objects that exhibit self-propelled motion; taken together, these studies suggest that as long as something

moves like an animate agent, it will be identified as such (Heider & Simmel, 1944; for a review see Scholl & Tremoulet, 2000).

However, animate agents are not always in motion. Even in the case of static images, people still demonstrate an advantage for identifying animate agents over inanimate objects; remarkably, this can occur when the images are presented quickly (28ms) and in the far periphery (Thorpe, Gegenfurtner, Fabre-Thorpe, & Bulthoff, 2001). Studies presenting similar identification tasks and using event-related potential (ERP) recording methods have demonstrated differential activation to images of animals and inanimate objects (Thorpe, Fize, & Marlot, 1996). This difference has been shown to occur whether participants reported observing the images or not, suggesting that the identification of animates and inanimates may occur prior to conscious access (Zhu, Drewes, Peatfield, & Melcher, 2016). Clearly, there exists evidence for the animate advantage even in the absence of motion cues. The question is, what other cues might we be using to identify and attend to animate agents?

Faces are a likely candidate, as they contain perceptual systems (in particular, eyes) that can both facilitate goal-directed motion and convey emotions. Indeed, our attention to facial features emerges extremely early in life, as newborns exhibit a preference for looking at faces (Goren, Sarty, & Wu, 1975; Morton & Johnson, 1991), especially those that exhibit direct gaze (Farroni et al., 2002). Moreover, much of our overall attention to faces is focused on the eyes (for a review see Birmingham & Kingstone, 2009), and direct eye contact is both preferentially oriented and attended to longer, compared to other internal facial features such as the nose or mouth (e.g., Senju & Hasegawa, 2005; Haith, Bergman, & Moore, 1977). People are also sensitive to the emotional content of faces, showing, for instance, a difference in detection of threatening emotions over other, more positive expressions (e.g., Batty &

Taylor, 2003; Fox, Russo, Bowles, & Dutton, 2001; Hansen & Hansen, 1988). Thus, we appear to selectively attend to faces, and specifically to facial features that convey significant perceptual and emotional information. As these two functions can be extremely useful in predicting a self-propelled entity's next likely course of action, it is highly probable that the possession of facial features could act as a reliable signal of animacy in the absence of motion cues. As is the case with motion cues, it may be possible to demonstrate a hypersensitivity to faces by presenting them "out of context"; that is, to induce a mistaken judgment of animacy in objects which contain facial features, and to induce a mistaken judgment of *inanimacy* in animals which *do not* contain facial features.

1.3 The Present Experiments

Experiments 1a and 1b explored the influence of facial morphology in a speeded animacy judgment task. In experiment 1a, participants viewed a series of images that varied by the presence or absence of facial features (animals with faces, animals without faces, objects with faces, and objects without faces), and were asked to indicate whether each image was *animate* or not. Experiment 1b implemented a separate but parallel *inanimacy judgment task*, which was used to account for a possible endorsement bias in participants (e.g., Knowles & Condon, 1999); this task followed the same structure but required participants to indicate whether each image was *inanimate* or not. For both versions of the task, we predicted that:

(1) Consistent with previous findings, participants would demonstrate an advantage for identifying animals over objects.

In addition, we predicted that the type of image being presented (animal versus object) would interact with the presence or absence of facial features, such that:

(2) Participants would find it more difficult to categorize objects with faces as not animate (or inanimate), compared to objects without faces, and

(3) Participants would exhibit a similar level of difficulty in characterizing animals without faces as animate (or not inanimate), compared to animals with faces.

2. Experiment 1a – The Animacy Judgment Task

2.1 Methods

2.1.1 Participants

40 undergraduate students between the ages of 18 and 24 years were recruited for participation in this experiment (29 females; M_{age} = 18.80 yrs, SD_{age} = 1.32 yrs). All participants were students at the University of California, Santa Barbara (UCSB) who participated in this experiment for class credit.

2.1.2 Materials

Participants completed the animacy judgment task in individual cubicles within a quiet room; up to ten were tested at a time. Each cubicle was equipped with a desktop computer running Windows 7. The experiment itself was made using E-prime.

A total of 80 images were presented over the course of the task: 20 each of animals with faces, animals without faces, objects with faces, and objects without faces (see Figure 1 for examples). The animals with faces category depicted animals either facing the camera head-on or in side profile such that one or both eyes were clearly visible. The animals

without faces category depicted animals that typically lack facial morphology, such as certain insects or sea creatures. All images were acquired through an online image search, were resized to a uniform 576x624 pixels, and were displayed on a black background during the experiment.

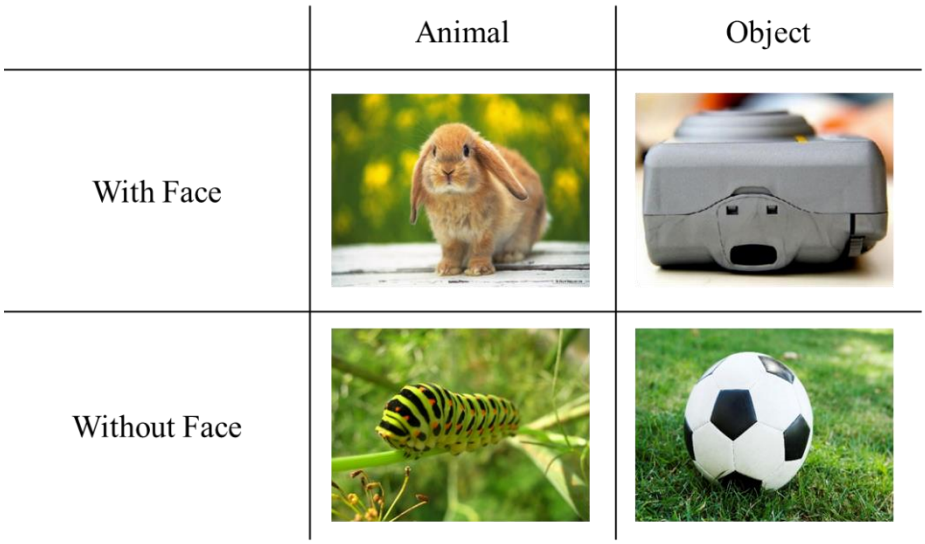

Fig. 1. Examples of each image category used in experiments 1a and 1b

2.1.3 Procedure

Participants were first instructed to place the index finger of their dominant hand on the down arrow key of the keyboard for the duration of the task. They then read through a set of instructions, during which they were shown examples of the different image types. Crucially, they were reminded that "Even though some of the objects look like they have faces, they are still *inanimate*." After completing a set of 8 practice trials, the test trials began. A single trial (see Figure 2) began with a blank screen which flashed for 500ms. Following that initial fixation, an image appeared in the center of the screen, with the prompt "Animate?" centered at the top and the choices "Yes" and "No" underneath it. Participants

were given 1000ms to answer “Yes” (left arrow key) or “No” (right arrow key) in response to the image. Feedback was then presented for 500ms, after which a new trial began. Participants were given two blocks of 40 test trials each, with a short break in between. The images in each block were pre-determined (e.g., “caterpillar” was always in block 1), but image presentation was randomized within each block, and the order of each block was counterbalanced across participants.

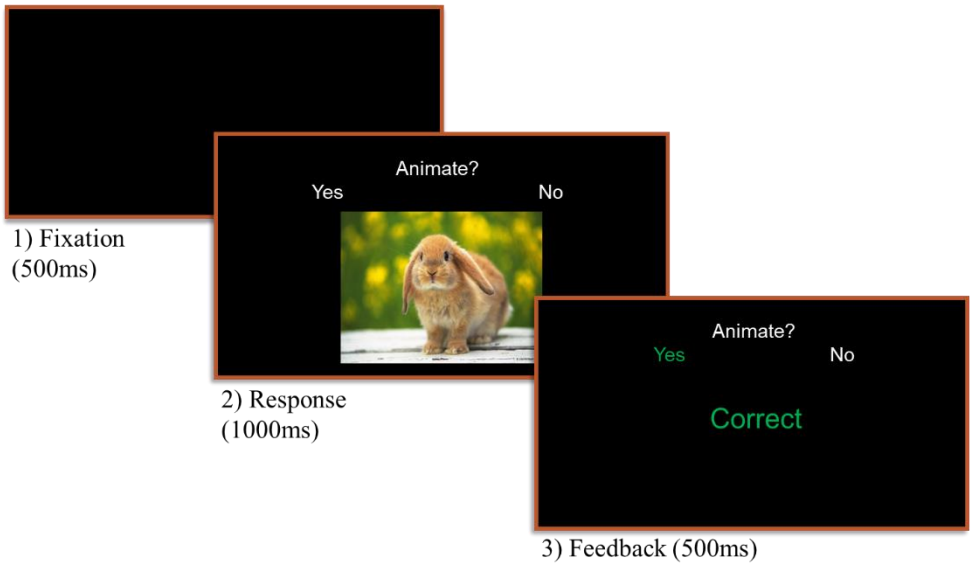

Fig. 2. Example of a single trial in the Animacy Judgment Task, Experiments 1a and 1b.

2.2 Results

We predicted that the presence or absence of facial information would influence judgments of animacy, such that participants would have more difficulty attributing inanimacy to objects with faces and attributing animacy to animals without faces. To assess the relative difficulty of each image category we calculated an inverse efficiency score as the

average response time divided by the average proportion of correct responses, with a higher inverse efficiency score indicating a greater amount of difficulty for a given condition (Townsend & Ashby, 1979).[1] For the sake of comprehensibility, we will refer to it hereafter as an *inefficiency score*. Individual item analyses are included in the supplementary materials for this chapter.[2]

2.2.1 Effects of image type and the presence or absence of facial features on inefficiency scores

We first conducted a 2 (face vs. no face) x 2 (animal vs. object) repeated-measures ANOVA to examine the effect of face presence on each image category (see Figure 3). The ANOVA revealed a non-significant main effect for the presence of facial features (F[1,39] = 1.62, p = .21, partial η^2 = .040), indicating that the mere presence of a face was not, on its own, more difficult to judge than the absence of one (M_{face} = 600.43ms, SD_{face} = 72.26ms, $M_{no\ face}$ = 592.99ms, $SD_{no\ face}$ = 76.05ms). There was a significant main effect for image category (F[1,39] = 32.00, p < .001, partial η^2 = .453), as images of animals were easier to judge compared to objects ($M_{animals}$ = 576.94ms, $SD_{animals}$ = 67.63ms, $M_{objects}$ = 616.48ms, $SD_{objects}$ = 80.69ms). However, this effect was qualified by a significant interaction between the two factors (F[1,39] = 32.31, p < .001, partial η^2 = .453), which indicated that the difference between the two types of images was largely driven by high performance on the

[1] The inverse efficiency score can provide a useful means of summarizing response time and accuracy data by collapsing them into a single measure of performance. This calculation is best used when both measures appear to be going in the same direction; that is, when slower responses are less accurate, or when faster responses are more accurate. As our data exhibited the former pattern of performance, we chose to use this calculation in the main analyses reported here. Response time and accuracy data are presented separately in the supplementary materials.

[2] Individual trials were removed if they fell outside of 3 standard deviations of the mean response time for each participant. We set an exclusion criterion for any participant who required removal of more than 1.25% (10 out of 80) trials. No participants met this criterion for experiment 1a.

animals with faces category. Taken together, these results suggest that the extent to which facial information influences judgments of animacy depends on whether the image depicts an animal or an object.

Simple main effects analyses indicated that participants found it much easier to judge animals with faces compared to objects with faces (t[39] = 7.28, p < .001, d = 1.15; $M_{anim.\ w/face}$ = 566.31ms, $SD_{anim.\ w/face}$ = 69.51ms; $M_{obj.\ w/face}$ = 634.55ms, $SD_{obj.\ w/face}$ = 75.01ms). In contrast, performance on animals and objects without faces was roughly comparable (t[39] =

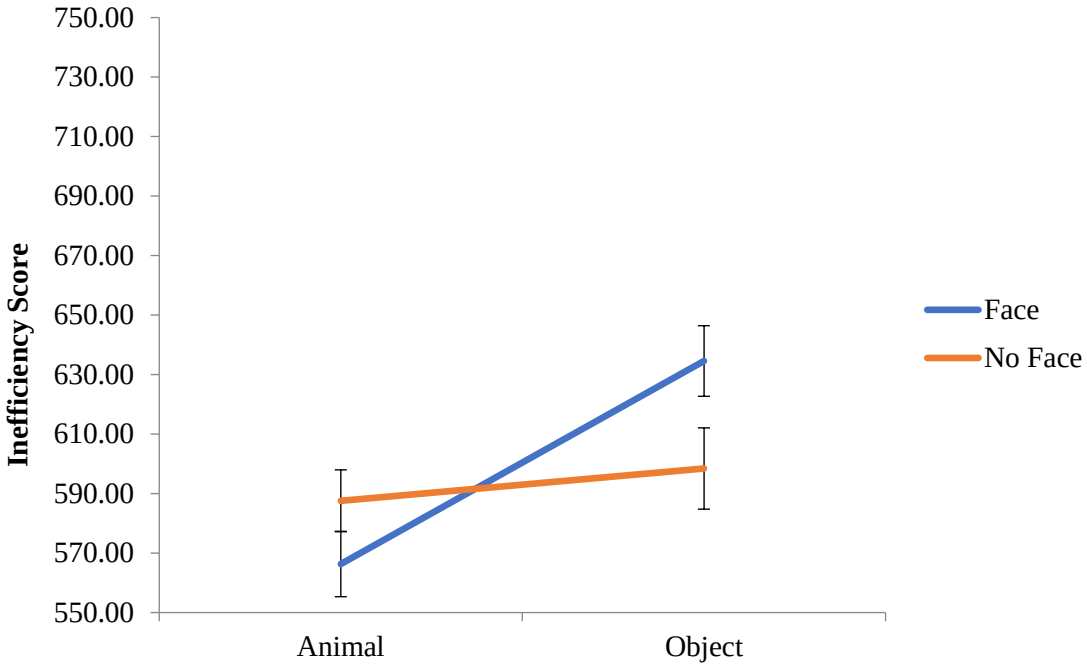

Fig. 3. Comparison of the effects of the presence of facial information for each image type in experiment 1a. Higher inefficiency scores indicate greater difficulty in responding correctly to the given stimulus category. Error bars represent +/- 1 standard error.

1.40, p = .169, d = 0.22; $M_{anim.\ w/o\ face}$ = 587.56ms, $SD_{anim.\ w/o\ face}$ = 65.74ms; $M_{obj.\ w/o\ face}$ = 598.42ms, $SD_{obj.\ w/o\ face}$ = 86.37ms). Similarly, animals were much easier to judge when they

had visible facial features compared to when they did not, while the opposite was true for objects (t[39] = 3.83, $p < .001$, $d = 0.61$; t[39] = 3.84, $p < .001$, $d = 0.61$, respectively). These results were highly consistent with our predictions, demonstrating that the presence of facial features can speed correct judgments of animacy and slow correct judgments of inanimacy.

3. Experiment 1b – The Inanimacy judgment task

Although the results from experiment 1a were consistent with our stated predictions, we were concerned that participants' response patterns were indexing a general bias to choose "Yes" over "No" (e.g., Knowles & Condon, 1999). This might have, at least in part, accounted for the difference in inefficiency scores between the animal and object categories. The Inanimacy Judgment Task was thus used to account for the possibility of an endorsement bias in the original Animacy Judgment Task. If this bias was in fact skewing responses, we predicted that participants would make fewer errors when categorizing objects with faces as inanimate (i.e., selecting "Yes"), and would make more errors when categorizing animals with faces as not inanimate (i.e., selecting "No"). Conversely, if the endorsement bias was *not* driving participant responses, then the pattern observed in Experiment 1a would be maintained.

3.1 Methods

3.1.1 Participants

The sample consisted of 42 undergraduate students who received class credit for their participation (37 females; M_{age} = 18.76 yrs, SD_{age} = 0.85 yrs). Students who had previously completed experiment 1a were not permitted to participate in experiment 1b.

3.1.2 Materials and Procedure

Each participant completed the inanimacy judgment task in a testing room equipped with computer cubicles – the same room and computers as were used in experiment 1a. The same 80 images used in Experiment 1a were presented in the inanimacy judgment task (see Figure n above). A single trial followed the same ordering and timing as experiment 1a (see Figure n above), except here the prompt at the top of the screen read “Inanimate?” rather than “Animate?”.

3.2 Results

As stated previously, we predicted two possible outcomes for experiment 1b. If participants were relying on an endorsement bias to respond to the stimuli, we would expect to see a reversal of the pattern in experiment 1a; that is, participants would be more efficient at judging objects as inanimate (i.e., indicating “Yes”) than judging animals as not animate (i.e., indicating “No”). Alternatively, if the presence or absence of facial information were interfering with judgments of animacy, we hypothesized that participants would again have more difficulty attributing inanimacy to objects with faces and attributing animacy to animals without faces. To assess the relative difficulty of each image category we again calculated an inefficiency score as the average response time divided by the average proportion of correct responses, with a higher inefficiency score indicating a greater amount of difficulty. Individual trials were removed if they fell outside of 3 standard deviations of the mean response time for each participant. We set an exclusion criterion for any participant who required removal of more than 1.25% (10 out of 80) trials. No participants met this criterion for experiment 1b.Individual item analyses are included in the supplementary materials for this chapter.

3.2.1 Comparative performance on experiment 1a and 1b

Except in terms of a uniform increase in inefficiency scores, the results from experiment 1b largely mirrored those of experiment 1a ($M_{exp.\ 1a}$ = 596.71ms, $SD_{exp.\ 1a}$ = 74.16ms; $M_{exp.\ 1b}$ = 626.39ms, $SD_{exp.\ 1b}$ = 98.21ms). An independent samples t-test indicated that this difference was not significant (t[80] = 1.54, p = .123, d = 0.34). It is highly probable that the difference in performance was driven by the presence of a negative in the prompt (i.e., here participants had to endorse the images as either *inanimate* or *not inanimate*), which may have increased both processing time and the overall tendency to make errors. Crucially, it does not appear that the change altered participants' ability to make judgments of animacy or inanimacy, as the increase in efficiency was consistently higher for all image types in the experiment.

3.2.2 The influence of image type and the presence or absence of facial features on inefficiency scores

To examine these effects, we again conducted a 2 (face vs. no face) x 2 (animal vs. object) repeated-measures ANOVA. Results were highly consistent with experiment 1a, with a significant main effect for image category (F[1,41] = 32.07, p < .001, partial η^2 = .439), but not for the presence of facial information (F[1,41] = 0.84, p = .37, partial η^2 = .020; see Figure 4). As with experiment 1a, there was no significant influence of the mere presence or absence of facial features (M_{face} = 628.61ms, SD_{face} = 94.11ms, $M_{no\ face}$ = 624.18ms, $SD_{no\ face}$ = 102.30ms), and participants found it much easier to judge animals compared to objects ($M_{animals}$ = 606.51ms, $SD_{animals}$ = 98.29ms, $M_{objects}$ = 646.28ms, $SD_{objects}$ = 98.12ms). Also consistent with experiment 1a, here too the main effect of image type was qualified by a significant interaction between the two factors (F[1,41] = 11.47, p = .002, partial η^2 = .219), demonstrating that, as in experiment 1a, the difference was largely driven by the animals

with faces. Here again the presence or absence of facial features differentially affected performance for images of animals and objects.

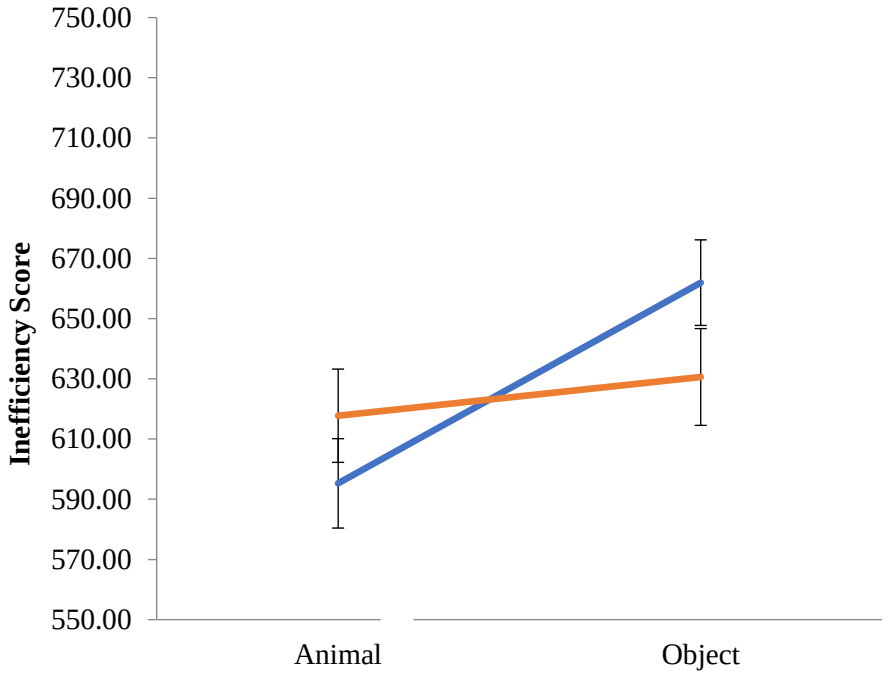

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Fig. 4. Comparison of the effects of the presence of facial information for each image type in experiment 1b. Higher inefficiency scores indicate greater difficulty in responding correctly to the given stimulus category. Error bars represent +/- 1 standard error.

The results from experiment 1b were remarkably consistent with experiment 1a. More importantly though, both experiments provided us with a preliminary confirmation of our predictions. In both cases we observed a general advantage for detecting animates compared to inanimates, and a robust effect of facial information – the presence of a face speeded correct judgments of animacy for animals, and slowed correct judgments of inanimacy for objects. This effect was apparent regardless of whether participants were asked to provide a positive ("yes") or negative ("no") response to the different stimuli, indicating that the differences in performance across each image type were more likely due to the sensitive nature of facial information in detecting animates.

5. Experiment 2 – The Animacy Categorization Task

In implementing the animacy and inanimacy judgment tasks, we demonstrated that the presence or absence of facial features can interfere with accurate judgments of animacy. Consistent with our predictions, we found that objects with faces were difficult to categorize as *inanimate*, both in terms of a slower response time for correct responses, and a comparatively higher rate of errors across all other conditions. This pattern was consistent across both experiments, indicating that the results from experiment 1a were not due to an endorsement bias.

Less clear-cut was the case of animals without faces: compared to animals with faces, participants were slower to make correct judgments, but the overall performance difference was only marginally significant. This could be due to a number of factors. For one, the overall error rates were quite small across both experiments, suggesting that despite the consistent pattern of differential performance we obtained this was a fairly easy task for participants to complete. Performance across conditions might be at ceiling, though this does

not fully account for the lower performance in objects with faces. A more important consideration is the fact that many of the images in this category depicted animals that are encountered less frequently than animals with faces; perhaps in this case participants were able to identify animals with faces more quickly simply because they are encountered more frequently. Alternatively, it may be the case that in the absence of facial features, other morphological cues (e.g., limbs, fur) may not be sufficiently strong to provoke a decisive judgment of animacy, but rather lead one to seek out more information before deciding; this would also account for the increased difficulty in the animals without faces condition, although our design did not allow us to test for this possibility. The influence of morphology on goal attribution has been demonstrated in infants (e.g., Woodward, 1998), but this can be subject to interference by other textural cues (e.g., Guajardo & Woodward, 2004), and overall suggests a more much more nuanced relationship among non-facial features. The comparative influence of different morphological cues on judgments of animacy is an important question for future studies to address.

Results from experiments 1a and 1b suggest that facial morphology can slow judgments of inanimacy (when present in objects) and speed judgments of animacy (when absent in animals). However, it is possible that this pattern could have been driven by a number of different factors in our set of images. As discussed above, the difference in inefficiency scores between the two animal categories may have been influenced by a familiarity effect, as many of the animals with faces are common and encountered more frequently in day-to-day life, and many of the animals without faces are considerably less familiar. Similarly, the difference between the two object categories may be explained by visual salience effects, as the objects with faces were depicted against a naturalistic

background, while the objects without faces were presented against a uniform background (often solid white), which could make the latter images easier to process regardless of the absence of facial features. Finally, some of the images of objects depicted plants or food items, which may have been subject to ambiguous interpretation; even though plants are animate entities, people have a difficult time recognizing them as such, most likely due to the fact that they do not exhibit perceivable self-propelled motion. Based on these concerns, we made significant changes to our image for experiment 2.

In addition to our concerns with the images from experiment 1, we conjectured that more general features of the task's design may have been influencing participant performance. That is, the difference in inefficiency scores between the animal and object categories may have been partially influenced by the prompt. Specifically, having to respond in the negative (i.e., indicating "No" to the "Animate?" prompt) may have caused a slight delay in response time or decrease in accuracy for the objects category, regardless of the presence of faces. Moreover, the low error rates across all four image types indicated a possible ceiling effect, which would cause any differences in performance to appear smaller. In Experiment 2, we attempted to address all of these issues by inducing more errors, changing the prompt, and providing more closely matched sets of images.

5.1 Methods

5.1.1 Participants

82 undergraduate students (61 females; M = 18.73 yrs, SD = 1.40 yrs) participated in this study for class credit. Students who had already participated in experiment 1 were not permitted to take part in experiment 2.

5.1.2 Materials and Procedure

As we stated previously, it is possible that the pattern of performance observed in experiment 1 could have been driven by a familiarity effect for the animal category, and visual salience effects for the objects category. In experiment 2 we attempted to correct for these discrepancies in image presentation by devising more reasonably matched sets of images for our animals and objects.

Animals with and without faces. We altered this set such that both conditions used the same set of animals, but in the face-present condition the entire face (eyes and mouth, facing forward or in side profile) was visible, and in the face-absent condition each animal was presented facing completely away from the camera, with no visible facial features. To control for possible familiarity effects, we replaced some of the more familiar images with those of less-common animals (e.g., pangolin and okapi instead of dog and cat; see supplementary materials for a full list of changes).[3]

Objects with and without faces. In the objects category, we again used the same set of objects for both the face-present and face-absent conditions. To match the two image sets we digitally "scrambled" the face-present images (using Adobe Photoshop) so that all of the visual information was preserved, but the images hypothetically no longer resembled faces. In scrambling the images, we focused on the first of the three levels of configural face processing, here described by Maurer, Le Grand, and Mondloch (2002) as: "(a) detection of 'first order' relations, which define the basic arrangement of a face, that is, the fact that face detection relies on a layout of features such that two eyes appear above a nose, which lies

[3] Because we chose to find images via online search, we were somewhat limited in the types of animals we could use for this set. We prioritized finding images that met our front- and back-facing criteria.

above a mouth; (b) holistic processing, which coheres the features into a perceptual gestalt; and (c) sensitivity to second-order relations, that is, the specific spatial arrangement within the face or perceiving the distances between features" (see Figure 5 for an example, and supplementary materials for all of th

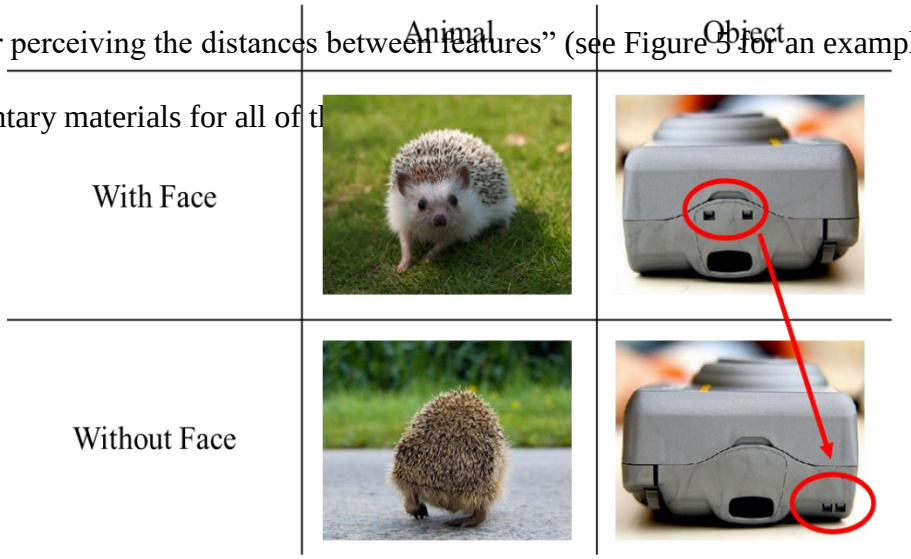


Fig. 5. Examples of each image category used in experiment 2, the Animacy Categorization Task.

To ensure each image was properly scrambled, we created an online survey wherein participants were asked to rate the extent to which each image displayed a series of emotional adjectives (using a scale ranging from 1 “Not at all” to 4 “Very much”). The emotional adjectives were comprised of the basic emotions as specified by Ekman, Friesen, and Ellsworth (1972): happy, sad, angry, and afraid. As an attention check, we also chose five physical properties based on the shape, texture, and color of the image presented. In order to control for random responding, one of the physical adjectives was always blatantly incongruent with the image. Any participant who selected one or more blatantly incorrect physical attributes were excluded from the analysis.

109 participants were tested using Amazon mTurk. Nine were removed from the dataset for random responding (5 from the unaltered images, 4 from the scrambled images). This amounted to a total of 100 participants: 47 rated all of the original, unaltered images (25 females; M_{age} = 38.7 yrs , SD_{age} = 12.2 yrs), and 53 rated the new, scrambled images (24 females; M_{age} = 35.9 yrs , SD_{age} = 8.4 yrs). To ensure the scrambled images were altered enough to remove all facial information, we compared emotion ratings on the unaltered and scrambled surveys (see supplementary materials for ratings of each image). This was done by first calculating a boundary score for each image as the highest-rated emotion for the unaltered image minus 1.5 the standard deviation of all of the emotion ratings for the unaltered image. For an image to be considered sufficiently scrambled, all of the emotion ratings for the scrambled image had to be less than this score; if not, they were re-scrambled and tested again. Nine scrambled images fell within this criterion; these were rated again in a separate survey by 49 additional participants (18 females; $Mean_{age}$ = 44.0 yrs, SD_{age} = 13.3 yrs), after which they were accepted via the aforementioned criteria.

Changes in the general design of the task. In addition to improving the image sets, we also made several changes to the general design of the Animacy Judgment Task. To completely control for any possible influence of negative responses to the prompt, in experiment 2 we asked participants to simply categorize each image as either "object" or "animal." We also reasoned that changing the level at which participants would be required to make judgments from animate-inanimate to animal-object would render the prompt less subject to ambiguous interpretation. That is, although we defined animacy and inanimacy for participants in the instructions, we could not be certain they were relying solely on these guidelines to make judgments.

Additionally, in order to account for a possible ceiling effect in error rates for experiment 1, in experiment 2 we significantly decreased the image presentation time. A single trial in experiment 2 went as follows (see Figure 6): after a 500ms fixation screen an image was flashed for 100ms. Participants were then shown a blank screen with the two category choices at the top; they were given 1000ms to categorize the image as either "Animal" (left arrow key) or "Object" (right arrow key) in response to the image. Feedback was then presented for 500ms, after which a new trial began. The presentation of the "animal" and "object" prompts was counterbalanced, such that for half of the participants the word "animal" was on the left-hand side of the screen, and for half of the participants it was on the right.

As in experiment 1, participants were given 8 practice trials, followed by 80 test images (20 images in each category). They were tested in the same room and under the same experimental conditions as participants in experiment 1.

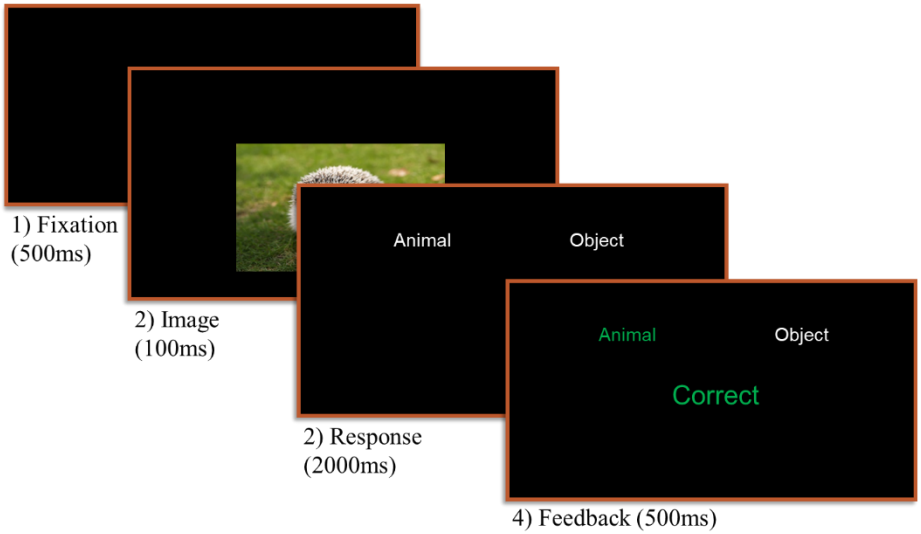


Fig. 6. Example of a single trial in experiment 2, the Animacy Categorization Task.

5.2 Results

Here we again predicted that participants would demonstrate an advantage for detecting animals compared to objects, and a differential effect of the presence or absence of facial features when correctly categorizing images of animals and objects. We again calculated an inefficiency score (average response time divided by proportion of correct responses) to test our predictions. Individual trials were removed if they fell outside of 3 standard deviations of the mean response time for each participant. We set an exclusion criterion for any participant who required removal of more than 1.25% (10 out of 80) trials. Three participants met this criterion for experiment 2; our final dataset thus included 79 participants. Individual item analyses are included in the supplementary materials for this chapter.

As a preliminary step, we wanted to examine whether overall performance differed between participants who saw the “animal” prompt on the left or right side of the screen. To

examine this, we conducted a 2 (animal vs. object) x 2 (face vs. no face) x 2 (animal-object vs. object-animal) mixed ANOVA with image type and face presence as within-subjects factors, and prompt ordering as a between-subjects factor. The analysis revealed non-significant interactions for prompt condition and image type (F[1,77] = .140, p = .710, partial η^2 = .002), prompt condition and face presence (F[1,77] = .828, p = .366, partial η^2 = .011), and for the three-way interaction among prompt condition, image type, and face presence combined (F[1,77] = 1.43, p = .235, partial η^2 = .018). Because we found no significant interactions with the ordering in the prompt, we collapsed across this factor for further analyses.

5.2.1 The influence of image type and the presence or absence of facial features on inefficiency scores

Next, to test our primary hypotheses the data was entered into a 2 (face vs. no face) x 2 (animal vs. object) repeated-measures ANOVA (see Figure 7). The analysis revealed a non-significant main effect for the presence of facial features (F[1,78] = 2.01, p = .16, partial η^2 = .025), with no difference between their mere presence or absence (M_{face} = 294.98ms, SD_{face} = 71.55ms, $M_{no\ face}$ = 299.92ms, $SD_{no\ face}$ = 66.29ms). We also found a significant main effect for image type (F[1,78] = 62.90, p < .001, partial η^2 = .446). Consistent with our predictions, animals were easier to categorize compared to objects ($M_{animals}$ = 283.02ms, $SD_{animals}$ = 65.76ms, $M_{objects}$ = 311.88ms, $SD_{objects}$ = 72.08ms), although a significant interaction between the two factors (F[1,78] = 17.18, p < .001, partial η^2 = .181) indicating that this was once again driven by the animals with faces category. Taken altogether, the results from experiment 2 were consistent with experiment 1 in demonstrating that facial

features will differentially influence performance depending on whether the image is of an animal or an object.

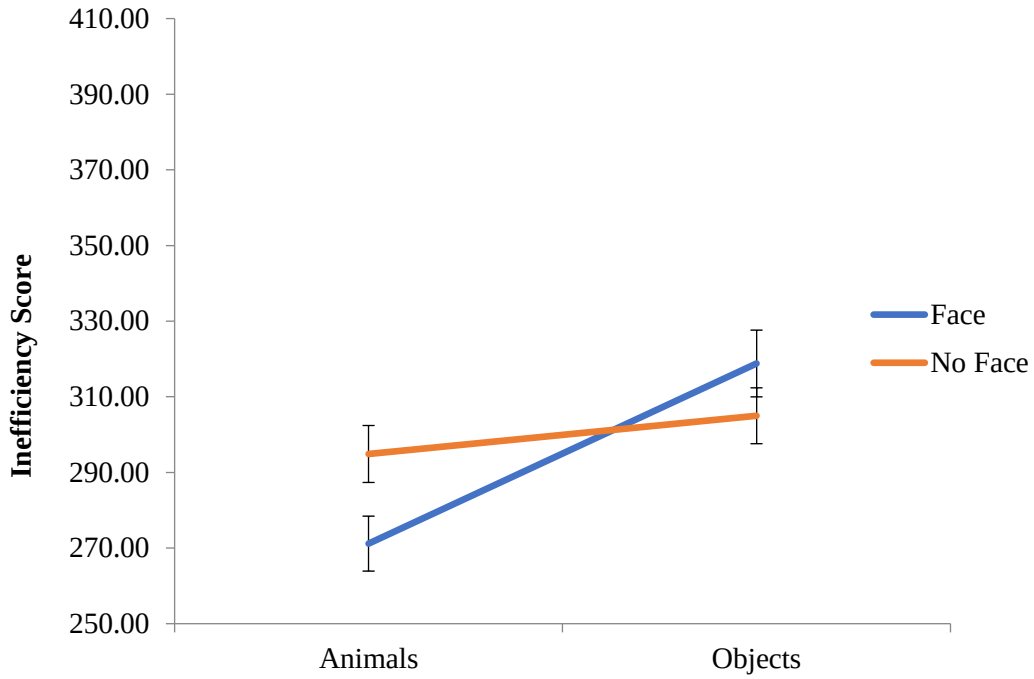


Fig. 7. Comparison of the effects of the presence of facial information for each image type in experiment 2. Higher inefficiency scores indicate greater difficulty in responding correctly to the given stimulus category. Error bars represent +/- 1 standard error.

Simple main effects comparisons were largely in line with the results obtained from experiment 1. Participants once again performed better when categorizing animals with faces compared to objects with faces (t[78] = 7.42, p < .001, d = 0.83; $M_{anim.\ w/face}$ = 271.17ms, $SD_{anim.\ w/face}$ = 64.58ms; $M_{obj.\ w/face}$ = 318.80ms, $SD_{obj.\ w/face}$ = 78.52ms). Performance when categorizing animals without faces was marginally better than objects without faces (t[78] = 1.97, p = .052, d = 0.22; $M_{anim.\ w/o\ face}$ = 294.87ms, $SD_{anim.\ w/o\ face}$ = 66.94ms, $M_{obj.\ w/o\ face}$ = 304.97ms, $SD_{obj.\ w/o\ face}$ = 65.64ms), which was also relatively consistent with experiment 1a.

We again found that animals were easier to categorize when they had visible facial features, while the opposite was true for objects with faces ($t[78] = 5.79$, $p < .001$ $d = 0.65$, $t[78] = 1.98$, $p = .050$ $d = 0.22$, respectively). It is of note that this latter difference – between objects with and without faces – revealed only marginal significance, which together with a relatively small effect size suggests that the two categories were more similar than expected. A breakdown of the data which separates response times from the proportion of errors (see graphs in the supplementary materials for this chapter) shows that the difference in inefficiency scores was likely driven by accuracy, as response times were roughly equal for the two types of objects. It is possible that the lack of a significant difference was due to noise induced by scrambling the images, which in turn could have caused participants to take longer when categorizing them, but which ultimately did not influence correct categorization. Despite this lack of significance, we feel that the it does not challenge our primary findings that the presence of facial features seems to interfere with the correct categorization of objects, and seems to aid in categorizing animals.

6. General Discussion

The results reported here highlight several important facets of animacy detection. First, across our two experiments we found tentative support for the so-called "animate monitoring hypothesis", which asserts that we are evolutionarily predisposed to preferentially notice and attend to animate agents in our surroundings (New et al., 2007). Participants were significantly and consistently better at identifying animals, compared to objects; however, we should note that this effect was largely due to the presence of animals with faces, which participants found easiest to categorize.

Second, across both studies we found the predicted effect for facial features presented "out of context": participants found it more difficult to judge animals *without* faces as animate (or animals), and objects *with* faces as inanimate (or objects). In the case of animals, the presence of a face can speed judgments of animacy; in the case of objects, it can considerably slow judgments of inanimacy. These results speak to the hypersensitive nature of animacy detection by showing that it is biased towards quick rather than accurate judgments. While this has been demonstrated repeatedly for motion cues, to our knowledge this is this first demonstration of hypersensitivity to facial features in static images.

Beyond a mere demonstration of hypersensitivity, the studies reported here provide tentative evidence for the prioritization of certain types of information in the detection of animates. One might expect a hypersensitive system to give equal priority to *any* cue of animacy, whether it be self-propelled motion, facial features, the presence of limbs, or the possession of certain textures such as hair or fur. But the pattern of results we observed for the animals without visible facial features suggests this may not be the case. Even though these animals possess other cues of animacy (e.g., limbs, contour, texture), and despite evidence (shown both here and elsewhere) for a general bias towards over-detecting animate agents in our surroundings, participants still had more trouble identifying animals as such when facial features were not visible, compared to when they were. If all animacy cues were processed equally, one might expect there to be no difference between these two sets of animals; however, this was not the case. It is possible, then, that when deciding whether something is animate or not, certain cues of animacy receive more weight than others. We suggest that more weight will be given to cues which provide the most reliable information about how an animate agent is likely to behave; this includes self-propelled and goal-directed

motion, and, as our findings suggest here, the presence of perceptual systems as indicated by facial features, especially eyes.

Finally, while there exists a wide body of literature on animacy detection in both dynamic and static stimuli, much of the focus has been in terms of distinguishing humans from inanimate objects (although see review by Johnson 2003 for studies describing motion cues in non-human animates). Humans, however, are but a subset of animate agents, and a complete account of how this system functions requires examining non-human agents as well. In the studies discussed here we demonstrated that facial features can act as a minimal cue of animacy in non-human, and in some cases non-agentive, entities. This suggests that animacy detection may be a necessary, but not sufficient, component of abilities that help us interact with other humans, such as theory of mind. A hint at this may be in studies which examine animacy detection in individuals on the autism spectrum. Although these individuals exhibit robust impairments in reasoning about intentionality (Castelli, Frith, Happé, & Frith, 2002; Klin, 2000), and show atypical patterns of attention to both faces (Pelphrey et al., 2002; Schultz et al., 2000) and biological motion (Blake et al., 2003; Klin et al., 2009), they have demonstrated an ability to make categorical distinctions between animates (both humans and non-human animals) and inanimate objects (New et al., 2010). This suggests that the detection of animate agents, and the application of higher mental states to such agents, may comprise distinct but related systems. Our present studies speak to this possibility as well, although this is only a start; research into the role of animacy detection in higher mentalizing abilities remains a rich area for future study.

CHAPTER 3

Animacy detection and the face inversion effect

1. Introduction

Among those who study face processing, researchers have documented what is commonly referred to as the face inversion effect, or the failure to recognize familiar faces when their orientation is inverted (Yin, 1969). This effect is most often studied in terms of face recognition; in a commonly used new-old recognition paradigm, participants first view images of faces presented in both upright and inverted orientations. They are then given a test in which a series of upright faces is presented, and for each face they are asked to indicate whether they have seen it before. A consistent finding from these studies is that participants are worse at recognizing faces when they are presented in an inverted orientation in the initial phase of the task.

These findings add to the ever-growing collection of evidence for a mechanism specialized for perceiving and individuating human faces (e.g., Ellis & Shepherd, 1975; Kanwisher, 2000; but see Valentine, 1988 for an alternative viewpoint). Diamond and Carey (1986) succinctly describe how we may differentially process human faces and inanimate objects or naturalistic scenes:

> Classes that do not share a configuration, such as two arbitrarily chosen landscapes or houses, may differ in the spatial relations among similar parts (e.g., the distance between a foreground rock and a background tree). These constitute what can be called first-order relational properties. However, for faces and other classes sharing a configuration, first-order relational properties are thereby constrained; members of

these classes are individuated by distinctive relations among the elements that define the shared configuration. We refer to these as second-order relational properties.

Under this view, human faces are easier to process because they share roughly the same features in the same configuration: two eyes, above one nose, above one mouth, all constrained within the boundary of the front of the head. Individuation occurs across so-called second-order relational properties, or minor variations in the appearance of each feature, or in the distance between features. Objects or landscapes, on the other hand, are much more varied in their appearance (not all houses contain exactly two windows above a door, and not all landscapes contain exactly three trees on top of a hill). These entities are individuated according to their first-order relational properties, which can be more difficult to attend to and encode in memory. Researchers who purport that face processing is done according to these constraints claim that when a human face is inverted, one's ability to process it along its second-order relational properties is disrupted. Instead, individuation must occur along its first-order relational properties, in much the same way as one would differentiate different objects or landscapes (Diamond & Carey, 1986).

There exists a wealth of research indicating that objects and faces are processed by different areas of the brain (e.g., Spiridon, Fischl, & Kanwisher, 2010; Tong et al., 2010; Jeffreys, 1996; for an early review see Kanwisher et al., 1996). This research extends to the inversion effect, as neuroimaging studies have demonstrated that inverted, but not upright, faces activate the same brain areas as upright and inverted objects, while upright and inverted objects do not activate the same brain areas as faces (e.g., Haxby et al., 1999). A striking demonstration of effect this can be seen in individuals who have impaired face processing

(prosopagnosia), and who perform better when recognizing previously inverted faces. This is thought to be because, when presented upright, these individuals rely on damaged face processing mechanisms to make judgments, but when inverted, they recruit the use of object processing mechanisms to aid them (Farah et al., 1995). On the opposite end of prosopagnosia studies are case studies conducted on an individual with visual object agnosia, who displays intact face recognition abilities but impairments in recognizing both objects and inverted faces (Moscovitch, Winocur, & Behrmann., 1997). Taken together these studies point to separate, dissociable systems for processing faces and objects; when inverted, recognition of human faces appears to recruit the latter more than the former.

That the mind seems to rely on separate systems for individuating faces and objects suggests that, beyond *recognition*, the *perception* of these different entities may be controlled by different mechanisms. This leads to an important question: to what extent will inverting a face impede one's ability to *detect* it as such? While many neuroimaging studies have found increased activation of object processing mechanisms for inverted faces, they have also pointed out that inversion does not significantly decrease activation in face detection areas (e.g., Kanwisher, Tong, & Nakayama, 1998; Haxby et al., 1999). Moreover, studies that employ both behavioral and neuroimaging techniques have found that while participants are indeed slower at perceiving inverted faces, they rely on the same regions of the face for detection in either orientation (Sekuler et al., 2004; Richler et al., 2011). Sekuler et al. (2004) have suggested that the difference between upright and inverted orientations is qualitative, rather than quantitative; that is, the upright advantage may be primarily due to an expertise effect (as faces are most often encountered in an upright orientation), but the face perception system may still ultimately be able to detect inverted faces as such.

It may be possible to examine the extent to which inversion disrupts face perception by exploring it at a functional level. That is, we can assess the extent to which inversion preserves face perception by seeing if inverted faces can be used as input for the animacy detection system – a system which is purportedly biased towards rapid detection of animate agents (e.g., New et al., 2007). To the extent that faces provide a significant cue of animacy, this system should hypothetically allow for some amount of variance in orientation. In experiments 1 and 2, we demonstrated that the presence of facial features can negatively impact judgments of inanimacy and the correct categorization of objects; these judgments were not impaired when the first-order relational properties of the face were disrupted via scrambling. And while inverting faces has also been shown to disrupt the encoding of second-order properties as it relates to *recognition*, behavioral and neuroimaging research has suggested that this may not completely inhibit the *detection* of faces. It may be the case, then, that unlike the scrambled faces used in experiment 2, inverted faces may still be perceived as such, and may thus have a similar negative effect on judgments of animacy or correct categorization.

Alternatively, it is possible that inversion will still impede face perception as it pertains to animacy detection and animal-object categorization. This would be the case if input to the animacy detection system exhibited similar constraints as facial recognition, only accepting variance along second-order relational properties. Studies which have examined the inversion effect in change detection paradigms suggest that that this may indeed be the case, as they have found that inverting both humans and animals removed their advantage over objects (New et a., 2007; Ro, Russel, & Lavie, 2001).

1.1 The Present Study

Here we propose a design that may lend insight into the mechanisms behind the inversion effect as it pertains to superordinate-level (i.e., animal-object) categorization. Using the same animacy categorization task as experiment 2, here we attempt to demonstrate the effects of presenting both animals and objects with facial information in both upright and inverted orientations. Unlike experiments 1 and 2, here we did not predict an animate advantage, as previous studies have demonstrated that this effect is not present under inversion. With regards to comparative performance, we predicted two possible outcomes:

(2a) If inversion sufficiently disrupts face perception, then the pattern of responses should be roughly comparable to the deficit for scrambled objects and animal backs from experiment 2. On the other hand,

(2b) If this system is sensitive enough to perceive inverted faces as such, then the inverted images should elicit a comparable degree of efficiency to their upright counterparts. That is, performance within the two animal conditions, and within the two object conditions, should be roughly equal.

2. Experiment 3

2.1 Methods

2.1.1 Participants

88 undergraduate students (60 females; M_{age} = 18.51 yrs, SD_{age} = 0.91 yrs) participated in this experiment for class credit. Students who had already participated in previous animacy experiments were not permitted to participate in experiment 3.

2.1.2 Materials

Participants completed the animacy judgment task in individual cubicles within a quiet room; up to ten were tested at a time. Each cubicle was equipped with a desktop computer running Windows 7. The experiment itself was made using E-prime.

A total of 80 images were presented over the course of the task, with 20 images in each of four categories: upright animals with faces, a matched set of inverted animals (i.e., the same images were used for both categories, with the only difference being their orientation), upright objects with faces, and a matched set of inverted objects. The images in experiment 3 were the same as those presented in the animals with faces and objects with faces categories from experiment 2.

2.1.3 Procedure

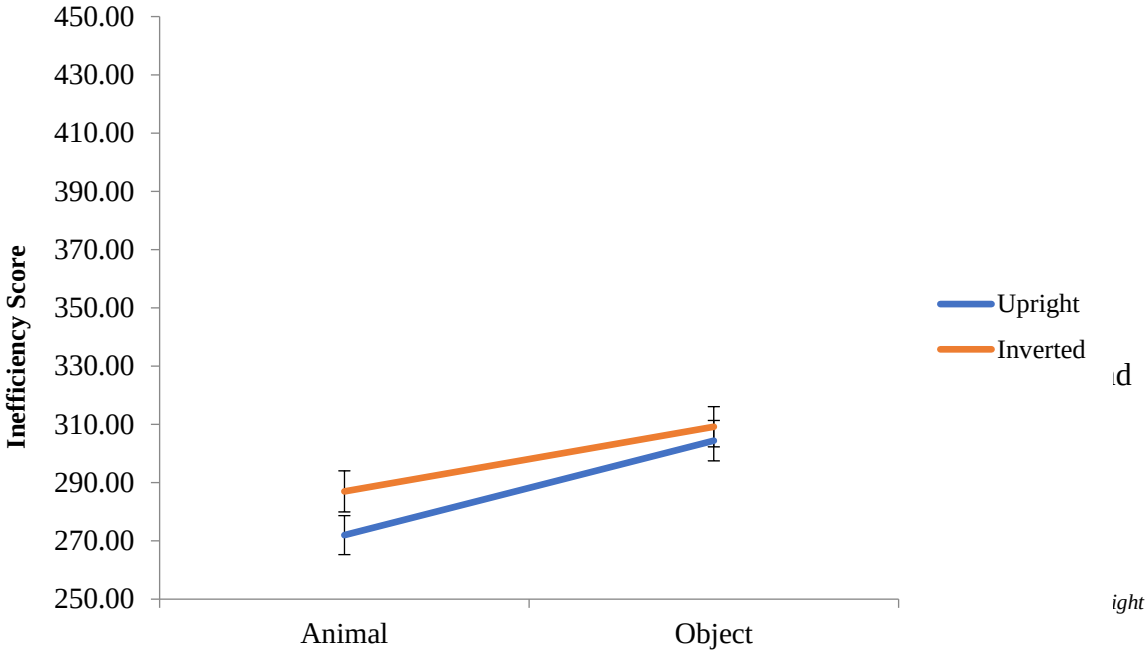
Participants were first instructed to place the index finger of their dominant hand on the down arrow key of the keyboard for the duration of the task. They then read through a set of instructions, during which they were shown examples of the different image types. Crucially, they were reminded that "Even though some of the objects look like they have faces, they are still *inanimate*." After completing a set of 8 practice trials, the test trials began. A single trial followed the same timeline as in experiment 2 (see Figure 6 in Chapter 2), and again required participants to sort images into "animal" and "object" categories. The presentation of the "animal" and "object" prompts was again counterbalanced, such that for half of the participants the word "animal" was on the left-hand side of the screen, and for half of the participants it was on the right. Participants were given two blocks of 40 test trials each, with a short break in between. The images in each block were pre-determined, but image presentation was randomized within each block, and the order of each block was counterbalanced across participants.

2.2 Results

With regards to comparative performance, here we predicted two possible outcomes. If inversion disrupts facial processing, then inverted animals should be more difficult to categorize, and inverted objects should be easier to categorize, compared to their respective upright counterparts. On the other hand, if the animacy detection system is sensitive enough to perceive faces in an inverted orientation, then performance should be comparable within the animals and objects conditions, respectively. To test our predictions, we again calculated an inefficiency score as the average response time divided by the proportion of errors, with a higher inefficiency score indicating worse performance for a given category of images. Individual trials were removed if they fell outside of 3 standard deviations of the mean response time for each participant. We set an exclusion criterion for any participant who required removal of more than 12.5% (10 out of 80) trials. 8 participants met this criterion for experiment 3; the final dataset thus included 80 participants. Individual item analyses are included in the supplementary materials for this chapter.

We first conducted analyses to examine whether overall performance differed between participants who saw the "animal" prompt on the right or left side of the screen. A 2 (upright vs. inverted) x 2 (animal vs. object) x 2 (animal-object vs object-animal) mixed ANOVA was conducted, with orientation and image type as within-subjects factors, and prompt ordering as a between-subjects factor. The analysis revealed non-significant interactions for prompt condition and image type (F[1,78] = 3.57, p = .062, partial η^2 = .044), prompt condition and orientation (F[1,78] = .640, p = .426, partial η^2 = .188), and for the three-way interaction among prompt condition, image type, and orientation (F[1,78] = .597, p = .442, partial η^2 = .008). Because we found no interaction effects between the ordering of

the words in the prompt and our other two factors, we collapsed across this variable in further



= 60.98ms, $M_{inverted}$ = 298.08ms, $SD_{inverted}$ = 62.41ms), and animals were also easier to

Fig. 1. Comparison of the effects of the presence of facial information for each image type in experiment 3. Higher inefficiency scores indicate greater difficulty in responding correctly to the given stimulus category. Error bars represent +/- 1 standard error.

Simple main effects analyses indicated that upright animals were significantly easier to categorize than upright objects ($t[79] = 9.32$, $p < .001$, $d = 1.11$; $M_{upright\ animals} = 271.98$ms, $SD_{upright\ animals} = 59.89$ms; $M_{upright\ objects} = 304.40$ms, $SD_{upright\ objects} = 62.08$ms); this may have been due to an advantage for detecting animals, to the presence of facial features in the images of objects, or to some combination thereof. Providing minor support for an animate advantage, we did find that inverted animals were easier to categorize than inverted objects ($t[79] = 5.27$, $p < .001$, $d = 0.59$; $M_{inverted\ animals} = 286.99$ms, $SD_{inverted\ animals} = 63.10$ms; $M_{inverted\ objects} = 309.18$ms, $SD_{inverted\ objects} = 61.72$). When comparing performance within each image category, the analyses revealed that while animals were easier to categorize when presented in an upright orientation ($t[79] = 5.47$, $p < .001$, $d = 0.61$), objects in either orientation were comparably difficult to categorize ($t[79] = 1.38$, $p = .172$, $d = 0.15$). The implications for these findings are discussed below.

3. General Discussion

The goal of the current study was to examine the inversion effect as it pertains to categorization of animals and objects. We had two predictions: by demonstrating no effect of

inversion, we would lend support to the possibility that inversion does not disrupt face detection, and for a system that allows for significant variance in orientation. Alternatively, by demonstrating greater difficulty for inverted animals and lower difficulty for inverted objects, we would lend support for the inversion effect at the perceptual level, and for input constraints on the animacy detection system. Unfortunately, the results we obtained did not fall neatly into one interpretation or the other.

3.1 Inverted animals were more difficult to categorize than upright animals, but easier to categorize than objects

It is not entirely clear that the orientation of facial features *in particular* was driving either of these differences. As we discussed in Chapter 1, self-propelled motion and facial features are not the only cues of animacy. Prior research has suggested that other morphological features, such as the presence of limbs or certain textures associated with animals (such as skin or fur), can also act as animacy cues (e.g., Guajardo & Woodward, 2004). Taken in the context of our results, this provides an intriguing possibility. It may be the case that these other features were aiding categorizations of animacy, to the point that it did not matter whether the animal had a face or not. That is, the presence of limbs or certain textures may have been sufficient for an ultimately correct categorization regardless of orientation, albeit not to the same degree of efficiency as their upright counterparts.

3.2 Performance on upright and inverted objects with faces was roughly equal

While objects on the whole were more difficult to categorize than animals, it is not entirely clear why this was the case. While it is entirely possible that inverting faces does not stop them from being perceived as such, we cannot rule out the possibility that the two

categories elicited similar levels of performance for different reasons. Prior work has shown the influence of expertise effects on recognition abilities, in that participants who are either experimentally trained or self-declared experts in individuating a given object exhibit the inversion effect to a comparable degree as when recognizing different faces (e.g., Diamond & Carey, 1986; Gauthier & Tarr, 2002). These findings may extend to object perception; regardless of whether or not facial features were detected, the inverted objects in our study (which were all likely to be highly familiar and easy to identify) might have been more difficult to categorize simply because they were more difficult to perceive as such. And while it may be possible that the presence of facial features had an effect despite their inverted orientation, our experimental design did not enable us to dissociate this from the difficulty of identifying inverted objects. This was an unfortunate oversight, but it has lead us to devise modifications for future studies that may ultimately tell us more about this effect.

3.3 Conclusions

Though the results from this experiment are decidedly less conclusive than those from experiments 1 and 2, we still feel they are important to include here. To our knowledge, this is one of the first studies examining the inversion effect at the level of explicit superordinate-level categorization. With a few notable exceptions (e.g., Troje & Westoff, 2006) the vast majority of studies which examine this effect do so using human faces. As we discussed in the previous chapter, it is highly probable that animacy detection is a necessary, but not sufficient, condition for identifying humans. This is supported by findings from studies conducted with individuals on the autism spectrum, who have not only demonstrated a difference in detecting animals and humans in a change detection paradigm (e.g., New et al., 2010), but also show differential activation for humans and animals in the distributed face

network (Whyte et al., 2015). If animal and human faces are processed differently, it is important to understand which cues are relevant in making this distinction. An important first step, which we have attempted to take here, would be to examine how face detection functions in non-human, and even non-animate, entities.

Ultimately, we feel that this experiment was not as well-controlled as it could have been. However, we do feel that examining the inversion effect as it pertains to animacy detection (and superordinate-level categorization) is still an important area of research. One obvious modification for the object condition would be to invert the facial features while leaving the rest of the image in an upright orientation; this would allow us to isolate the effects of facial orientation while removing object orientation as a possible confound. Inverting only the faces in the animal condition might disrupt the ecological validity of the images too greatly, but one viable alternative would be to examine the role of inversion in categorizing upright and inverted animals when they are facing forward or away from the camera (essentially using the same images from experiment 2, but presenting each image in either orientation). With some careful adjustments, we believe that this methodology has the potential to produce interesting, and decidedly more conclusive, results.

CHAPTER 4

Facial features can act as a reliable cue of animacy in early childhood

1. Introduction

From birth, we are tasked with bringing order to a world filled with information. At this early stage, ordering is not accomplished through explicit categorization, but rather by the automatic delineation of certain aspects of the environment. Our visual systems define

physical objects via features such as borders, shading, and depth; achieving that, we are then faced with a more complex problem – where to direct our limited attention? This should perhaps be guided by opportunities to learn about and process the world around us, and as we are fundamentally social beings (e.g., Cosmides & Tooby, 1992), it follows that we should direct some of this attention toward opportunities that allow for social interaction. This necessitates an ability that enables us to distinguish between inanimate objects and animate agents; such a system has been proposed by early researchers in this field (Leslie, 1994; Premack, 1990). Indeed, it appears that this ability begins to emerge just hours after birth, as newborns preferentially attend to animate agents in their surroundings: they prefer to look at facial arrays (Morton & Johnson, 1991), and at entities which appear to move on their own (Di Giorgio, Lunghi, Simion, & Vallortigara, 2017). The emergence of this preference to attend to properties of animates so early in life speaks to the possible existence of a core cognitive structure – an innate system which provides a skeletal framework for further learning about animate agents.

1.1 Motion and morphological cues of animacy in infancy

Although newborn studies on animacy detection are few and far between, those that exist provide compelling evidence for the early existence of a specialized system which, at the very least, differentiates animates from inanimates. These studies are bolstered by findings from a wealth of work on infants, conducted during the first two years of life, that give the overwhelming impression not only of a general preference for attending to animates, but also a capacity for interpreting the behavior of animate agents in terms of intentional states such as goals and desires. By the second year of life infants are able to: infer the intentions of human, but not mechanical, actors (e.g., Meltzoff, 1995; Woodward, 1998),

attribute dispositions and preferences to animate agents (e.g., Song, Baillargeon, & Fisher, 2005; Song & Baillargeon, 2007), demonstrate an understanding of socially causal behaviors such as chasing (e.g., Schlottman & Surian, 1999; Rochat et al., 1997; Rochat et al., 2004), and infer helping and hindering behaviors from the movements of simple shapes (e.g., Hamlin, Wynn, & Bloom, 2007), to name just a few (for a comprehensive review see Opfer and Gelman, 2011). The overwhelming conclusion from these studies is that infants appear to possess a core system for attending to and reasoning about animate agents.

How does this system develop in the first two years of life? In one of the first studies on early goal-encoding, Woodward (1998) demonstrated that infants are able to interpret the repeated reaching of a hand towards one of two objects as goal-directed, but do not extend the same interpretation to an inanimate rod. Interestingly, while this ability was apparent at six months, it was much less consistent in five-month-olds; at this age they were able to differentiate between the animate and inanimate entities, but did not reliably attribute the motion of the former as goal-directed. Woodward (1998) proposed that this ability must undergo some fundamental change over the first few months of life, most likely as infants gain firsthand experience with the world around them. Sommerville, Woodward, and Needham (2005), for example, found that three-month-old infants were able to encode the goals of an actor's reach, but only after they were given an opportunity to handle the target objects themselves. Infants at this age are unable to grasp objects on their own, so they were given Velcro mittens which allowed them to handle the objects; the authors interpreted their findings as an indication that infants' specific skills require direct experience to develop.

An alternative possibility is that infants are able to make these inferences at an earlier age, but require more specific information regarding when they should apply them. An

important prediction from this perspective is that infants should also be able to make intentionality-based inferences about *any* entity as long as it provides specific cues. Much of the work in support of this perspective has been conducted with regards to the interplay between dynamic cues (e.g., self-propelled motion) and static cues (e.g., morphology). With regards to the former, infants appear to place specific constraints on self-propelled motion. For example, beyond simple self-propulsion along a straight pathway, an entity must also select a rational trajectory in pursuit of its goal (e.g., Gergeley et al., 1995; Csibra et al., 2003; Kamewari et al., 2005), or must exhibit equifinality – movement towards a consistent goal despite changes in position relative to that goal (e.g., Johnson, Shimizu, & Ok, 2007; Luo 2011b). In the absence of an observable motion trajectory, contingent reactivity with other animate agents can act as a sufficient signal (e.g., Spelke, Phillips, & Woodward, 1995; Johnson et al., 2003). It seems that on its own self-propelled motion is neither necessary nor sufficient to elicit judgments of animacy; rather, it becomes more powerful the more it suggests the intentional pursuit of goals.

Can the same be said for morphological cues? Prior work has suggested that morphology is not necessary to make judgments of animacy, as entities which exhibit rational, equifinal, and/or contingently reactive self-propelled motion need not resemble a human or non-human animal to be considered an animate agent (e.g., Csibra, 2008; Luo & Baillargeon, 2005); this is the case for infants as young as three months of age (Luo 2011b). On the other hand, morphology may become more important in the absence of dynamic cues. Johnson, Booth, and O'Hearn (2001), for example, demonstrated that infants will make social overtures toward a stuffed orangutan, but not a lamp, after watching an experimenter carry out a one-sided conversation with each. Faces in particular seem to be a powerful cue,

as infants will, for example, follow the gaze of an inanimate object with salient facial features after it orients itself in a specific direction (Johnson, Slaughter, & Carey, 1998).

Of particular importance seems to be the presence of eyes. An attentional preference for looking at eyes (as opposed to other facial features) becomes apparent at just two months of age (Farroni et al., 2002), and by three months of age infants will spontaneously follow the gaze of an adult to a specific target (Willen, Hood, & Driver, 1997).[4] While this suggests that infants use eyes as a way to obtain information about an animate agent's likely next course of action, it does not necessarily mean that the mere presence of eyes will elicit judgments of animacy. Indeed, a study by Meltzoff et al. (2010) showed that 18-month-old infants will only follow the gaze of an animate robot to a target object when it reacts contingently with a human experimenter. These results provide an interesting caveat to those obtained by Johnson et al. (1998); while infants in Johnson et al.'s study spontaneously looked in the same direction as an entity with a face, they did not connect the entity's gaze to a target object. It may thus be the case that eyes can provide a significant initial cue of animacy, but – as is the case with motion cues – will not lead to strong judgments of animacy in the absence of more information. The extent to which this initial cueing occurs and influences subsequent judgments of animacy remains a rich area of exploration, and is the topic of the current experiments.

1.2 The animate-inanimate distinction in early childhood

[4] Other work suggests that younger infants rely on a combination of head orientation and gaze cues (e.g., Scaife & Bruner, 1975), and are not able to solely rely on gaze cues until around 14 months of age (e.g., Moore & Corkum, 1998). It seems highly likely that infants use both gaze and orientation to gather information about an animate agent's goals or desires, but may afford different weights to different cues at different ages.

How does reasoning about animacy develop after the first two years of life? By and large, research on animacy detection in early childhood has tended to focus on explicit grouping into living or non-living entities (as a proxy for the animate-inanimate distinction), or into animal and object categories (i.e., superordinate-level categorization), rather than spontaneous inferences about animate agents. This shift seems to be due at least in part to the acquisition of language which occurs around this time; in studying this age range researchers are able to implement the more direct, explicit methodologies that have classically been used in early developmental research.[5] One important question, however, is the extent to which explicit, superordinate-level categorization tasks tap into children's core understanding of the animate-inanimate distinction. Do children rely on the same cues as infants – mainly, self-propelled motion and specific morphological features? If so, to what extent do these cues help inform their ability to make superordinate-level categorizations, and, more broadly, the ability to *explicitly* distinguish between animates and inanimates?

Piaget (1929) was arguably the first researcher to document so-called "childhood animism," or the tendency to over-attribute animacy to inanimate entities, most especially to non-living natural phenomena (such as rivers or clouds) and to inanimate vehicles (such as cars or bicycles). From these studies he concluded that until around 11 years of age children will assume that any entity which exhibits self-propelled motion is animate. In recent decades, Piaget's methods have come under criticism, and with them some of the conclusions that have been drawn from his studies (e.g., Carey, 1985). With regards to the animate-inanimate distinction, there now exists a wealth of evidence speaking to children's early

[5] By "explicit" or "direct" we are referring to methods that require children to either answer questions or complete tasks that are thought to directly measure the ability of interest. Whether or not these methodologies *actually* measure the ability of interest is an important and ongoing area of inquiry in conceptual development research.

competencies. By five years of age children are able to extend perceptual, psychological, and biological properties to animates, but not inanimates (e.g., Jipson & Gelman, 2007), including the capacity for growth (e.g., Inagaki & Hatano, 1996), and death (e.g., Barrett & Behne, 2005), among many other abilities unique to animate agents (for a review see Opfer & Gelman, 2011). If children are able to differentiate between animates and inanimates, what information do they use to inform this distinction?

In spite of the often-noted methodological issues with Piaget's work, findings from his studies on childhood animism may have actually provided an early indication of the relevance of motion cues. This becomes especially apparent when one considers the wealth of studies demonstrating the robustness of this suite of cues in other age groups. Indeed, research suggests that young children use the capacity for self-propelled motion as a distinguishing factor between animates and inanimates (e.g., Rhodes & Gelman, 2009). Moreover, to the extent that over-attribution errors occur, they appear to do so in the presence or absence of self-propelled motion. For example, Margett and Witherington (2011) found that while four-year-old children were largely able to correctly categorize animals and objects into respective living and non-living categories, they had significantly more trouble categorizing animates that do not exhibit observable motion (such as plants) as living, and inanimates that appear able to move on their own (such as bicycles) as non-living. Beyond the capacity for simple self-propelled motion, children seem to require indications of goal-directed action to make attributions of animacy. In a study by Opfer (2002), for example, five-year-old children attributed biological properties to animated blobs that moved towards a goal, but not to blobs that appeared to move aimlessly. However, it seems that as long as an entity exhibits relevant motion cues, it need not bear a physical resemblance to animate

agents; for example, Barrett et al. (2005) showed that preschool-aged children are able to identify specific, socially relevant motion patterns (such as playing, fighting, chasing, etc.) from the movements of simple shapes. As with infants and adults, children seem to use motion cues to distinguish animates from inanimates.

Do children place similar weight on morphological cues? Research suggests that the attentional preference for faces (and especially eyes) persists through childhood (e.g., Taylor et al., 2001). In terms of explicit categorization, a study by Massey and Gelman (1988) demonstrated that preschool-aged children will attribute internally generated motion to images of unfamiliar animals, but not to those of unfamiliar objects. These results were particularly interesting in that, beyond revealing an assumption that animate entities should exhibit relevant motion cues, they suggest that children can use morphological cues to infer a capacity for internally generated motion. It is entirely possible, then, that for preschool-aged children, morphological cues – specifically facial features – can act as a strong cue of animacy in the absence of motion cues.

1.3 The role of executive function (EF) in the animate-inanimate distinction

Through the first decade of life, children gradually come to express a more nuanced understanding of what it means for something to be alive or animate. Though they are able to distinguish between animals and objects by their preschool years, until around age six they exhibit a reluctance to group plants and humans into this same category (e.g., Johnson, Mervis & Boster, 1992), and their understanding of life and death is based decidedly less on biological processes (e.g., Slaughter, Jaakkola, & Carey, 1999). What is the mechanism behind this change? One possibility is that a qualitative shift in conceptual understanding occurs shortly following the preschool years, as children transition from classifying animates

based on psychological properties (i.e., intentional states such as goals and desires) to biological properties (i.e., the capacity for growth and death; Carey, 1985). As children learn more about biological processes, they alter their definition of animacy and become more willing to, for example, group humans and plants into the same category as animals.

An alternative possibility is that apparent changes in children's expressed knowledge of animates and inanimates is due at least in part to improvements in executive functioning (EF), a cluster of loosely related abilities that include working memory, attentional shifting, and inhibitory control, and that underlie the planning and execution of goal-directed action (e.g., Zelazo & Frye, 1997; Miyake et al., 2000). EF abilities show a marked increase during the preschool years (e.g., Zelazo, Carter, Reznick, & Frye, 1997; Davidson, Amso, Anderson, & Diamond, 2006), and have been implicated in the development of many abilities that were initially thought to be due to a qualitative shift in conceptual understanding. Research on theory of mind development, for example, has found that increased performance on false belief tasks in preschool-aged children is at least partially due to age-related increases in inhibitory control, which enable the suppression of an incorrect default response (i.e., attributing a true belief to an actor) in favor of a less-intuitive correct response (e.g., Carlson, Moses, & Hix, 1998; Leslie & Polizzi, 1998; Carlson, Moses, & Claxton, 2004).

In terms of the animate-inanimate distinction, it is possible that an age-related improvement in performance may be at least partially explained by improvements in EF, specifically the ability to inhibit intuitive but irrelevant information.[6] There is some indication that inhibition plays a role in children's understanding of biological concepts, even

[6] By "intuitive" we are referring to information that activates a core domain of knowledge.

when age and IQ are controlled for (Zaitchik, Iqbal, & Carey, 2013). This is further supported by research that has found that adults over-attribute animacy to non-living natural kinds when placed under speeded conditions (Goldberg & Thompson-Schill, 2009), and that elderly adults and those with Alzheimer's Disease will make these same errors when given ample time to respond (Zaitchik & Solomon, 2008). With regards to the present studies, inhibition may be required in order to suppress a default attribution of animacy to objects with "out of context" facial information. The experiments discussed in this chapter set out to explore this possibility.

1.4 The Present Experiments

Here we present two experiments, the goal of which is to examine: 1) the role of facial features in children's ability to categorize animals and objects, 2) whether and how this ability improves as a function of age, and 3) whether categorization errors can be at least partially attributed to a more general difficulty in inhibiting a default response. As prior research suggests that preschool-aged children make few errors when categorizing at the superordinate level (i.e., animals versus objects), we set out to see if we could increase susceptibility to errors by including or excluding a potentially relevant cue of animacy – facial features. Using modified versions of the animacy categorization task described in the previous chapters, we tested children between the ages of three and six on images of animals and objects, both with and without visible facial features. In experiment 4 we administered a task in which we asked children to sort different images into animal and object categories, measuring the number of sorting errors they made as a function of the presence or absence of facial features. In experiment 5, children played a computer game in which they were presented with two images side-by-side and asked to "catch the animal" by pressing one of

two keys on a keyboard; here we were able to record both the number of errors and their response times in four specific scenarios. Across both experiments, we hypothesized that:

(1) Consistent with the experiments in the previous chapters, children would exhibit a general animate advantage – that is, they would perform better when identifying animals than when identifying objects.

(2) Facial features would have a similar effect on children, such that their presence would help them correctly categorize animals without faces, and (in experiment 4) would hinder the categorization of objects with faces.

In line with the discussion above indicating a general improvement in superordinate-level categorization abilities as a function of age, we predicted that children in our experiments would show similar age-related effects. However, it is also possible that, to the extent that facial features act as a persistent cue of animacy, their influence would not be entirely attenuated as age increases. Taking this into account, we predicted that:

(3) Performance would increase as a function of age, but the pattern of responses (from predictions 1 and 2) would still hold.

Finally, with regards to inhibitory control we predicted that :

(4) In addition to age, improvements in inhibitory control will also play a role in performance, but only in the case of objects with faces.

2. Methods

2.1 Experiment 4 – The Animacy Card Sort Task

2.1.1 Participants

70 children between the ages of 3 and 6 years of age participated in this experiment. Four children (all female) were discarded from the sample for lapses in attention throughout the experiment, bringing the total number included in the dataset to 66 (31 females; M_{age} = 53.6 mo, SD_{age} = 9.5 mo). Participants were recruited from MOXI Children's Museum in downtown Santa Barbara. Prior to each experiment session, consent was provided by obtaining written permission from each child's parent or legal guardian, and verbal assent from the children themselves.

2.1.2 Materials

Experiment 4 used a subset of the images from experiment 2. This was done for two reasons. First, by reducing the number of trials we were able to conduct a full session in approximately 5 minutes, which is a reasonable amount of time to expect preschool-aged children to engage in a task of this nature. Second, we were concerned that there was some degree of ambiguity in several of the images of objects that were used in experiment 2, in that some of them were composed of multiple objects which came together to form a face, and could be more difficult to classify as a single object. Although the adults in experiment 2 did not on average demonstrate more difficulty with these objects, we wanted to remove any possible source of ambiguity for this younger age group. Additionally, we were also somewhat limited by our need to print out tangible copies of each image; while the resolution for these images was sufficient for presentation on a computer, some of them came out too blurry when printed. For this and the aforementioned reason, in experiment 4 we decreased our image set to 32 images – eight from each of the four categories (see supplementary materials for a list of all images used in this experiment). Finally, because we were using so

few images, we decided not to include a matched set of the animal and objects categories; in this way, 8 unique animals or objects were included from each of the four categories.

2.1.3 Procedure

All testing took place on the second floor of the MOXI Children's Museum, at a large table in the main exhibit space. All children were administered the Day/Night Task first, followed by the Animacy Card Sort Task; the total duration for both tasks was 5-6 minutes. Once completed, children were given a sticker as thanks for their participation.

Animacy Card Sort Task. Setup consisted of two boxes, each with a picture affixed to the top – an animal with a face, an object without a face, and a deck of 34 cards (2 practice and 32 test cards). The ordering of each box was counterbalanced such that for 33 children the "object" box was on the left side, and for 33 children the "animal" box was on the left side. Before beginning the task, the experimenter would shuffle the cards using the following procedure: the deck was divided into an animal and an object pile, and each pile was shuffled separately. The cards were then placed into a single deck, such that no more than three of the same category (animal or object) appeared in a row. This was done to randomize the order of the images as much as possible while at the same time preventing children from inferring any pattern between draws. Once shuffled, the deck of cards was placed face down in front of the experimenter and out of reach of the participant.

At the start of the task, the child was seated in front of the two open boxes, with the experimenter seated to their right side. Children were told that they would be shown one picture at a time, and would have to sort the pictures into one of the two boxes (see supplementary materials for a full version of the script). As in experiments 1-3, they were

told that even though some of the objects look like they have faces, they are still objects. The experimenter presented two practice trials before moving on to the task itself; if a child was unable to pass the practice trials on the first run, they were reminded of the instructions and the trials were presented again. If the child was still unable to pass the practice trials, the session was concluded and their data was excluded from the dataset. During the task itself, children were not given a time limit to respond, nor were they provided with feedback for their responses. Once this task and the Day/Night Task (see below) were concluded, the experimenter tallied up the incorrect cards in each box and recorded the number of correct responses for each of the four image categories.[7]

Day/Night Task. This task was adapted from the original version designed by Gerstadt, Hong, and Diamond (1994; see supplementary materials for a copy of the script), in which images are presented, one at a time, and the child must inhibit a default response to answer correctly. 14 cards (7 with a white background and a picture of a yellow sun; 7 with a blue background and a picture of a white moon) were shuffled into a single deck using the same procedure as described in the Card Sort Task. Two practice cards (one of each type) were placed at the top of the deck. At the beginning of the task, children were asked to name the picture on each card as a comprehension check, then were given the following instructions: "Whenever you see a picture of the sun I want you to say 'night', and whenever you see a picture of the moon I want you to say 'day.'" The child then given two practice trials; if they could not pass them the first time, the instructions were repeated and the trials were administered a second time. If the child was unable to pass the practice trials after two attempts, the session was concluded and their data was excluded from the dataset. Following

[7] Error rates for each individual image were not recorded in experiment 4.

the practice trials, the experimenter continued with the task, flipping each card up as fast as possible from the deck so that the child could see the image. Children were not given a time limit for their responses (although they were encouraged to respond as fast as possible), nor were they given feedback until the end of the task. Once this task and the Card Sort Task were concluded, the child was given a sticker as thanks for participating, and the experimenter tallied up the number of correct responses.

3. Results

We should note at the outset that overall performance was incredibly high for this task; however, a pattern of responses did emerge across the four image categories. Consistent with experiments 1-4, on average children made the fewest errors in the animals with faces category (M = 1.1%), followed by slightly more errors in the objects without faces category (M = 1.9%), slightly more still in the animals without faces category (M = 3.4%), and the greatest number of errors in the objects with faces category (M = 5.9%).

3.1 Counterbalancing: did the positioning of the boxes influence performance?

Prior to testing our main hypotheses, we first wanted to ensure that the position of the boxes did not significantly influence performance on our task. To test this possibility, we conducted a 2 (animal vs. object) x 2 (face vs. no face) x 2 (animal box on the left vs. right) mixed ANOVA using image type and face presence as within-subjects factors and box position as a between-subjects factor. The analyses revealed a significant interaction between box position and image type (F[1,64] = 7.94, p = .006, η_p^2 = .110). When the animal box was on the left, participants performed comparably well when categorizing animals and objects ($M_{animals}$ = 3.2%, $M_{objects}$ = 2.7%); however, when the animal box was on the right,

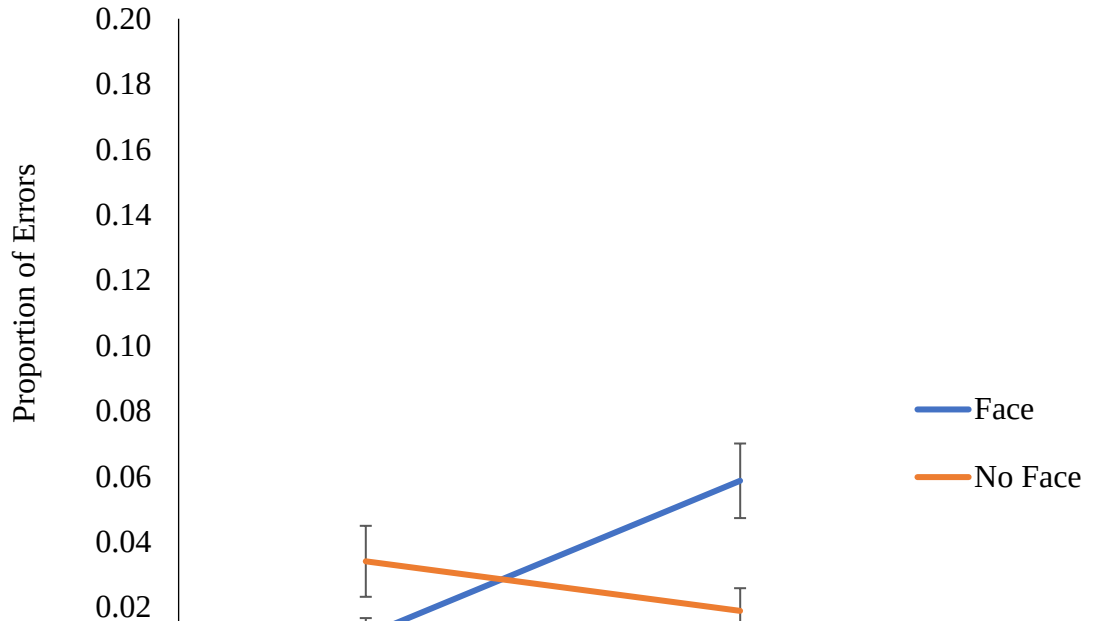
performance on animals was better than performance on objects ($M_{animals}$ = 1.3%, $M_{objects}$ = 5.1%). This was concerning, as it suggested that the results obtained here may have been somewhat overshadowed by the positioning of the boxes. However, we did not find an interaction between box position and face presence (F[1, 64] = 0.316, p = .57, η_p^2 = .005), nor did the three-way interaction among box position, image type, and face presence emerge as significant (F[1, 64] = 1.10, p = .298, η_p^2 = .017). Because of this, we ultimately chose to collapse across box position for our main analyses, with a caveat that any evidence for an animate advantage may have been due, at least in part, to the positioning of the boxes.

3.2 The influence of image type and the presence or absence of facial features on sorting performance

In order to examine our first two primary hypotheses, we next assessed performance across all age groups. Specifically, we predicted that children in this age range would also demonstrate a general advantage for correctly categorizing animals, compared to objects. We also predicted that the presence of a face would have a differential effect on each image category, such that performance would be better for animals with faces (compared to those without), and worse for objects with faces (compared to those without). To test this, we conducted a 2 (face vs. no face) x 2 (animal vs. object) repeated-measures ANOVA on the proportion of errors for each category (see Figure 1). The ANOVA revealed a marginally significant effect of image type (F[1,65] = 3.92, p = .052, η_p^2 = .057); consistent (albeit weakly) with our first prediction, animals were slightly easier to sort than objects ($M_{animals}$ = .02, $SD_{animals}$ = .07; $M_{objects}$ = .04, $SD_{objects}$ = .08). The main effect of facial features was non-significant (F[1,65] = 2.87, p = .095, η_p^2 = .042), as performance on images with visible facial features was roughly the same as on those without (M_{face} = .04, SD_{face} = .07; $M_{no\ face}$ =

.03, $SD_{no\ face}$ = .07). In line with our second prediction, the interaction between the two factors was highly significant (F[1,65] = 14.79, p < .001, η_p^2 = .185); the presence of facial features did indeed aid correct identification of animals and hinder correct identification of objects.

Simple main effects analyses indicated that children performed better when categorizing animals with faces compared to objects with faces (t[65] = 4.16, p < .001, d = 0.51; $M_{anim.\ w/face}$ = .01, $SD_{anim.\ w/face}$ = .04; $M_{obj.\ w/face}$ = .06, $SD_{obj.\ w/face}$ = .09), and found animals and objects without faces comparably difficult (t[65] = 1.31, p = .197, d = 0.16; $M_{anim.\ w/o\ face}$ = .03, $SD_{anim.\ w/o\ face}$ = .09; $M_{obj.\ w/o\ face}$ = .02, $SD_{obj.\ w/o\ face}$ = .05). This was highly consistent with adult performance on the animacy categorization task (experiment 2). However, in contrast to our results from the adult studies, here children performed significantly better in sorting both animals with faces compared to animals without faces (t[65] = 2.55, p = .013, d = 0.31), and objects without faces compared to objects with faces (t[65] = 3.91, p < .001, d = 0.48); the latter comparison had been non-significant in experiment 2. As objects without faces *should* be easier to categorize than objects with them, this was more of a concern to us with regards to experiment 2 than here.



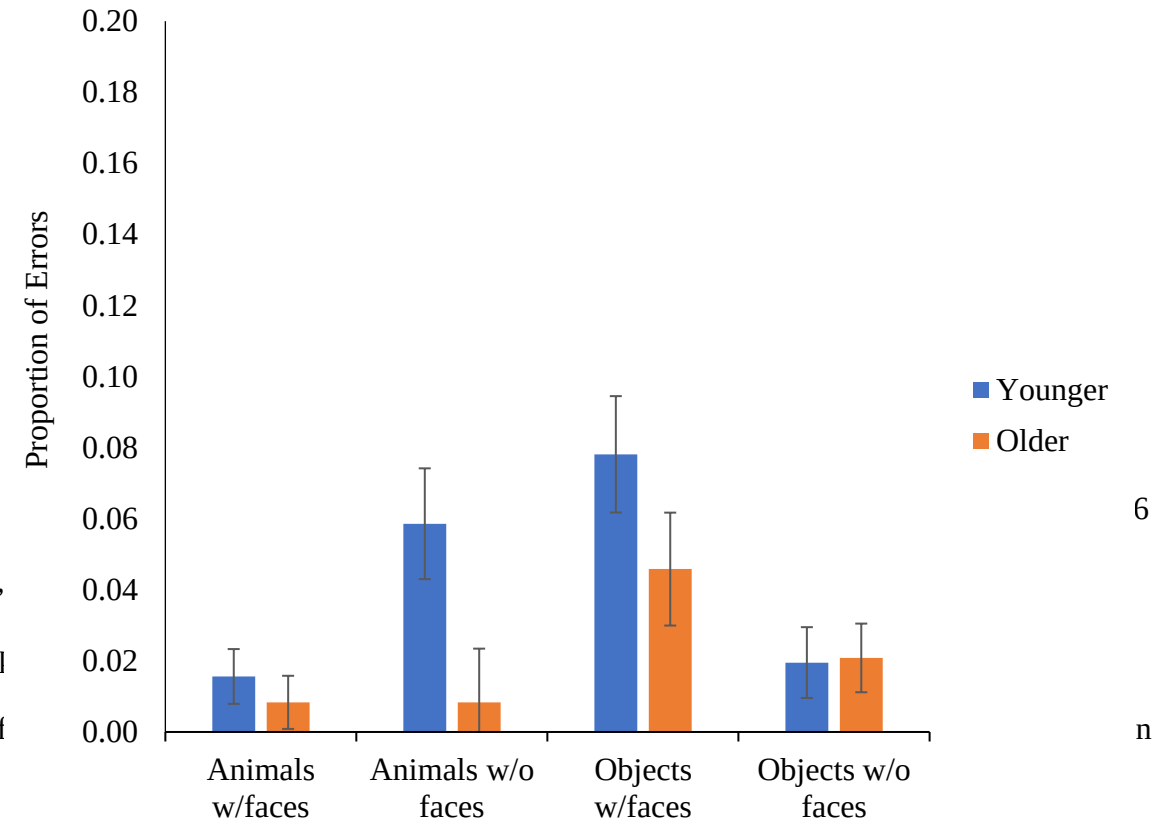


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Fig. 2. Performance on the Animacy Card Sort Task separated into younger (n = 32) and older (n = 34) age groups. Error bars represent +/- 1 standard error.

As we wished to assess the relative difficulty of each condition, we devised a strict coding system that accounted for the overall high performance across conditions. The number of errors in each category were coded on a pass/fail basis: a perfect score (8 out of 8) was coded as 1 (pass), and anything less (7 or less out of 8) was coded as 0 (fail). Because we were interested in how facial features influenced performance, we conducted binomial tests of change to compare the number of children who made errors when faces were present and absent to the number of children who made errors when faces were absent and present (see Table 1 for a summary of the results). We then conducted separate analyses for each image type (animal vs. object), and measured comparative performance across and between each age group.

Animals with and without faces. Across both age groups, most participants (52) were able to pass on both types of images, while only three children failed on both. Binomial chi-squared analyses revealed that more children correctly sorted animals with faces and incorrectly sorted animals without faces compared to those who showed the opposite pattern (9 vs. 2 children); however, this difference was only at trending significance (McNemar's χ^2 (1, N = 66) = 6.26, p = .065).

In the younger group, most of the participants were able to correctly sort both animal conditions, compared to a small fraction of the group who failed to correctly sort both conditions (23 vs. 3 children) Performance increased for the older group, with most children (29) able to pass both conditions; no children in this group failed both conditions. Analyses revealed that none of the younger children incorrectly sorted animals with faces and correctly sorted animals without faces, while a few children (6) incorrectly sorted animals without faces and correctly sorted animals with faces; this difference was significant (McNemar's χ^2

(1, N = 32) = 8.20, p = .031). While the same pattern emerged for older children, it was not as apparent compared to the younger group. More children correctly sorted animals with faces and incorrectly sorted animals without faces compared to the opposite pattern (3 vs. 2 children); this difference was not significant (McNemar's χ^2 (1, N = 34) = 0.20, p = 1.00). In sum, it appears that the extent to which a difference emerged between performance on animals with and without faces was driven by the younger group of children.

Objects with and without faces. Analyses which examined the influence of faces in the object categories found a similar pattern of results. As with the animal images, more participants passed on both types of objects than failed (40 vs. 6 children); this pattern was apparent in both the younger (17 vs. 3 children) and older (23 vs. 3 children) groups of children. In combining both age groups, the number of children who correctly sorted objects without faces and incorrectly sorted objects with faces was greater than those who showed the opposite pattern (18 vs. 2 children); this difference was significant (McNemar's χ^2 (1, N = 66) = 5.78, p = .023).

Similar to performance on the images of animals, here the differences also appeared to be driven by the younger group of children. More younger children incorrectly sorted objects with faces and correctly sorted objects without faces, compared to those who showed the opposite pattern (11 vs. 1 child); this difference was highly significant (McNemar's χ^2 (1, N = 32) = 1.76, p = .006). The same pattern was demonstrated for the older group, with more children incorrectly sorting objects with faces and correctly sorting objects without faces,

compared to the opposite pattern (7 vs. 1 child); however, the difference here only revealed a trending significance (McNemar's χ^2 (1, N = 34) = 4.41, p = .070).

Table 1

Crosstabs for Card Sort Task (8 correct = 1, 7 or fewer correct = 0)

			Younger (n = 32)		Older (n = 34)		Total (n = 66)	
			w/o face		w/o face		w/o face	
			Pass	Fail	Pass	Fail	Pass	Fail
Animals	w/face	Pass	23	**6** *	29	3	52	**9** ts
		Fail	**0** *	3	2	0	**2** ts	3
Objects	w/face	Pass	17	**1** **	23	**1** ts	40	**2** ***
		Fail	**11** **	3	**7** ts	3	**18** ***	6

*** p < .001, ** p < .01, * p < .05, ts p = .07

3.4 Performance, age, and inhibitory control

Taken altogether, our results thus far indicate that the influence of facial features is more pronounced for younger children, and appears to decrease as a function of age. This is consistent with a large body of prior work which has demonstrated that children become better at categorizing animals and objects as they move through their preschool years (for a review see Opfer & Gelman, 2011). However, we were curious as to whether or not this increase might be due (at least in part) to an improvement in inhibitory control, which would enable the suppression of a default response – in this case, deciding that an object with a face is not an animal. To test the extent to which inhibitory control played a part in this task, we first conducted analyses to examine whether age and performance on the Day/Night Task

(calculated as the proportion of errors) were correlated with performance on each of the four image categories (see Table 2 for a summary of the results).[8] Analyses for the Day/Night Task (M = 44.5% incorrect) revealed a significant relationship with age in months (r = .539, $p < .001$). The analyses also revealed a significant, positive relationship between age in months and performance on the objects with faces category (r = .352, $p < .01$); this was the only significant correlation for age. On the other hand, in examining the relationship between inhibitory control and the four image conditions, we found significant correlations for the objects with faces (r = .435, $p < .001$), the animals without faces (r = .333, $p < .05$), and the animals with faces (r = .343, $p < .01$). Altogether, these results are difficult to interpret, as we had only predicted a role for inhibitory control in the case of objects with faces, and we had predicted a general increase in performance as a function of age. With regards to inhibitory control, performance on the Day/Night Task was unusually low. Scores from the original study conducted by Gerstadt, Hong, and Diamond (1994) produced error rates ranging from 31.2-21.9% in children between the ages of four and five; these rates have been largely replicated across a number of implementations and modifications (for a review see Montgomery & Koeltzow, 2010). It is not entirely clear why our rates were so low here, although it is possible that conducting our study in a museum setting added a higher risk for distraction.

[8] 10 additional participants were discarded from these analyses because they were unable to pass the practice trials in the Day/Night Task. The analyses reported below are thus for a sample size of 56 participants (26 females; M_{age} = 53.7 mo, SD_{age} = 9.2 mo).

Table 2

Pearson Correlations between the four image categories, age, and inhibitory control

	Day/Night Score	Age (in months)
Animals w/Faces	.343**	.089
Animals w/o Faces	.333*	.211
Objects w/Faces	.435***	.352**
Objects w/o Faces	.201	.141
Day/Night Score	--	.539***

*** $p < .001$, ** $p < .01$, * $p < .05$

4. Experiment 4 Discussion

In replicating our results from experiments 1 and 2, here we provided preliminary evidence for both the animate advantage in early childhood and the role of facial information in categorizing animals and objects. Despite the overall high performance on this task, children performed better when categorizing images of animals, compared to images of objects. Children also found that animals with faces were easier, and objects with faces were more difficult, to sort into their correct categories. Additionally, we found evidence for improvement as a function of age, as the pattern of errors was most pronounced in the younger group of children, and seemed to be attenuated in the older group. In examining the interplay among performance, age, and inhibitory control, we found that age was only

correlated with objects with faces, while inhibitory control was related to everything except objects without faces.

5. Experiment 5 – The "Catch the Animal" Task

As a follow-up to experiment 4, experiment 5 implemented an adapted version of the Animacy Categorization Task which we modified for use with young children; we called this the "Catch the Animal" task. Our primary goals were to create a task: 1) that would afford us a more direct comparison between adult and child performance (by obtaining both response time and accuracy data and calculating a requisite inefficiency score), 2) whose directions were simple enough for young participants to follow, and 3) that was engaging enough to run through multiple, repetitive trials without participants losing interest. As such, instead of presenting images one-by-one and asking participants to categorize each, the Catch the Animal Task presented two images side-by-side and instructed participants to "Catch the animal as fast as you can!" by pressing one of two keys on a keyboard.

In addition, we also recruited a slightly older group of children for this task – between the ages of four and six years, as opposed to three and five. In experiment 4 we found a robust ceiling effect in performance; overall error rates were incredibly low, especially for the older group of children. While this was consistent with research demonstrating competence on animal-object categorization tasks in this age range, we wanted to see whether children at this age and above could still be prone to making errors under a more implicit measure of categorization. Here children were not asked to explicitly sort single images into one category or another; rather, they simply had to identify the animal as quickly as possible.

Our predictions here were consistent with those from previous experiments, but adjusted to reflect the nature of this particular task. By pairing animals with objects which contained (or did not contain) facial features, we could observe the extent to which facial information – notably, when presented out of context – can interfere with correctly identifying an animal. Generally speaking, we reasoned that animals with faces should be easier to select than animals without faces, and that objects with faces would interfere more than objects without faces. This led us to a specific prediction about the relative difficulty for each pair of objects:

(1a) *Animals with faces versus objects without faces.* This should be the easiest combination, as animals with faces should, on their own, be the easiest to identify, and as there is no facial information in the objects here.

(1b) *Animals without faces versus objects with faces.* This should be the hardest combination. The lack of facial features in the animals should render them more difficult to identify, while the presence of facial features in the objects should make them more susceptible to mis-identification.

(1c) *Animals with faces versus objects with faces.* This combination should be more difficult than 1a, but less difficult than 1b. Even though animals with faces should still be the easiest to identify, here we predict that the facial information in the objects would make them slightly more difficult to ignore.

(1d) *Animals without faces versus objects without faces.* This combination should also be fall somewhere in between 1a and 1b.[9] The lack of facial features in the animals should

[9] We do not have a strong prediction regarding comparative performance between 1c and 1d, other than them both falling somewhere in between 1a and 1b.

again make them more difficult to identify, but as the objects also lack facial information, they should not interfere with correct selection.

Additionally, as in experiment 4, here we predicted that both age and inhibitory control would factor into performance, such that:

(2) For all combinations, there would be an increase in performance as a function of age, but a consistency in the pattern of responses, and

(3) That this could be at least partially explained by an increase in inhibitory control, specifically regarding trials that require the suppression of a default response (i.e., in the animals without faces versus objects with faces combination).

5.1 Methods

5.1.1 Participants

35 children between four and six years of age participated in experiment 5. Six children were discarded because they were not able to pass the practice trials, bringing the total number included in the dataset to 29 (19 females; M_{age} = 63.4 mo, SD_{age} = 8.6 mo). Participants were recruited from MOXI Children's Museum in downtown Santa Barbara. Prior to each session, consent was provided by obtaining written permission from each child's parent or legal guardian, and verbal assent from the children themselves.

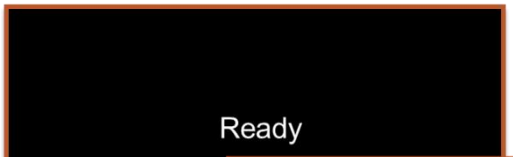
5.1.2 Materials and Procedure

Participants were first administered the Day/Night Task. Following that, they started the Catch the Animal Task. All participants were tested on a laptop computer running Windows 10 (screen resolution 1600x900 pixels). The experiment was created in E-prime,

and each image was resized to 576x624 pixels. 8 each of four possible combinations were presented: animal with face versus object with face, animal with face versus object without face, animal without face versus object with face, and animal without face versus object without face, for a total of 32 trials. The experiment was divided into two blocks of 16 trials, with each image being presented once in each block. The images in each combination were randomized.

Participants were seated in front of a computer screen which displayed the experiment. The experimenter sat to the side of each participant and used a mouse to click through the instructions and each trial. Participants were first told about the types of images they would be seeing; the experimenter emphasized that "some of the images will look like they have faces, but even if they do, they're still objects." Participants were then asked to place the index finger of their left hand on the "A" key and the index finger of their right hand on the "L" key. They were instructed to press the "A" key if the animal appeared on the left side of the screen, and the "L" key if the animal appeared on the right side. They were then given two practice trials to ensure they understood the directions. Following that, the experiment began.

A single trial (see Figure 3) started with a blank screen and the words "Ready" in the center. The experimenter read this aloud to ensure the child was paying attention; once this was confirmed they clicked through to the next screen, instructing the child to "Catch the animal as fast as you can!" as the images appeared. This screen presented two images, side-by-side, in one of the four possible combinations. Image presentation was randomized such that either the object or animal could appear on the left or right side of the screen.



6. Results

We predicted that participants' ability to correctly select the animal from the two provided images would be hindered either: 1) when the object appeared to have visible facial features, or 2) when the animal did not have visible facial features. To assess the relative difficulty of each image category we calculated an inefficiency score as the average response time divided by the average proportion of correct responses, with a higher inefficiency score indicating a greater amount of difficulty. Individual trials were removed if they fell outside of 3 standard deviations of the mean response time for each participant. We set an exclusion

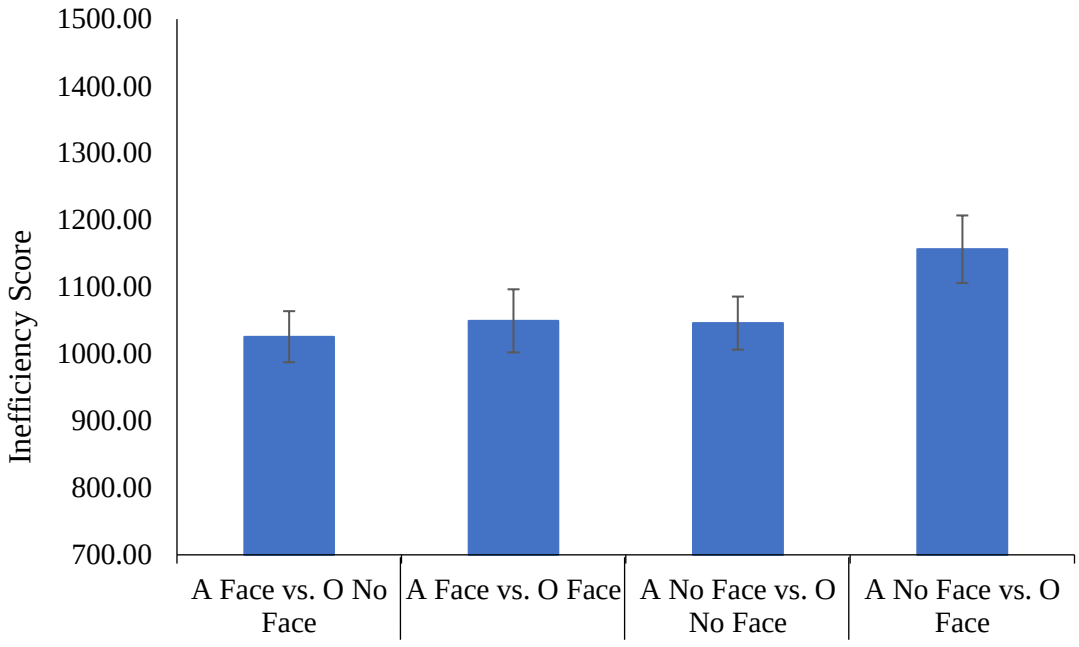
criterion for any participant who required removal of more than 12.5% (10 out of 80) trials; no participants met this criterion for experiment 5.[10]

6.1 Was the ability to correctly select the animal image impacted by the presence of an object with a face?

Our primary prediction was that animals with faces would be easier to select than animals without faces, and that objects with faces would interfere more than objects without faces. More specifically, we predicted that the animal would be easiest to select in the *animal with face versus object without face* combination, and would be hardest to select in the *animal without face versus object with face* combination. To test the relative difficulty among each combination, we first conducted a one-way ANOVA with image combination as a within-subjects factor. The analysis revealed a significant effect of image condition (F[1,84] = 4.31, p = .007, η_p^2 = .133). Figure 4 provides a graphical summary of the subsequent polynomial contrasts, which indicated a significant, increasing linear effect (F[1,28] = 7.74, p

[10] Because participants saw each image a twice during the experiment, we ran a preliminary analysis to examine whether performance was influenced by repeated presentation. We separated the first and second half of trials (16 trials in each block) and conducted a 2 (trial block) x 4 (image combination) repeated-measures ANOVA. Analysis revealed a significant main effect of trial block (F[1,28] = 5.36, p = .03, η_p^2 = .161); efficiency scores were overall higher in the first 16 trials, indicating an increase in performance with repeated image presentation ($M_{1st\ half}$ = 1020.27ms, $SD_{1st\ half}$ = 58.91ms; $M_{2nd\ half}$ = 989.83ms, $SD_{2nd\ half}$ = 42.54). The main effect of image condition was also significant (F[3, 84] = 6.81, p < .001, η_p^2 = .196). However, the interaction between the two factors was non-significant (F[3, 84] = .627, p = .600, η_p^2 = .022), which indicated that presenting each image twice did not significantly influence the pattern of performance beyond an increase in performance. Because of this, all further analyses were conducted using the total number of 32 trials.

= .01, η_p^2 = .216). In examining levels of efficiency for each image combination, we found that, as predicted, images in the *animal without face versus object with face* combination were the most difficult (*M* = 1064.91ms, *SD* = 271.70ms). However, there appeared to be little difference among the means for the *animal with face versus object without face* (*M* = 960.39ms, *SD* = 205.30ms), *animal without face versus object without face* (*M* = 971.70ms, *SD* = 213.38ms) and the *animal with face versus object with face* combinations (*M* = 996.58ms, *SD* = 253.73ms). Contrary to our predictions, images of *animals with faces versus objects without faces* did not emerge as the easiest combination. To the extent that there was a linear increase in difficulty, it appeared to be driven mostly by the *animal without face versus object with face* combination.



6 Fig. 4. Comparison of the four different image combinations in experiment 5 (A = Animal, O = Object). Higher inefficiency scores indicate greater difficulty in correctly selecting the animal in each pair. Error bars represent +/- 1 standard error.

To examine this more closely, we next used a median split to divide our sample into younger and older groups ($Median_{age}$ = 63.45 mo; $n_{younger}$ = 14, $M_{younger}$ = 55.86 mo, $SD_{younger}$ = 4.11 mo, n_{older} = 15, M_{older} = 70.53 mo, SD_{older} = 4.58 mo). Figure 5 depicts inefficiency scores for each age group in each combination of images. As in experiment 4, here we again predicted that performance would increase as a function of age. To test this, we conducted separate Friedman tests of differences to examine the effects of the four image combinations.[11] Analyses revealed a significant effect for the younger group ($\chi^2[3] = 17.91$, $p < .001$), but not for the older group ($\chi^2[3] = 2.68$, $p = .444$); it appears that the effects reported in the full sample were largely driven by the younger group of children. Subsequent Wilcoxon signed-ranks tests revealed differences in the younger group that were consistent with the full-sample analyses above: performance was the most difficult for the *animals without faces versus objects with faces* combination (*Median* = 1220.13ms), and this was significantly different from performance for the *animal with face versus object without face* (*Median* = 1043.08ms, $z = -2.67$, $p = .008$), the *animal without face versus object without face* (*Median* = 1044.17ms, $z = -3.05$, $p = .002$) combinations, and the *animal with face versus object with face* combination (*Median* = 1049.41ms, $z = -3.23$, $p = .001$). None of the other differences were significant (all *p*s = n.s.).

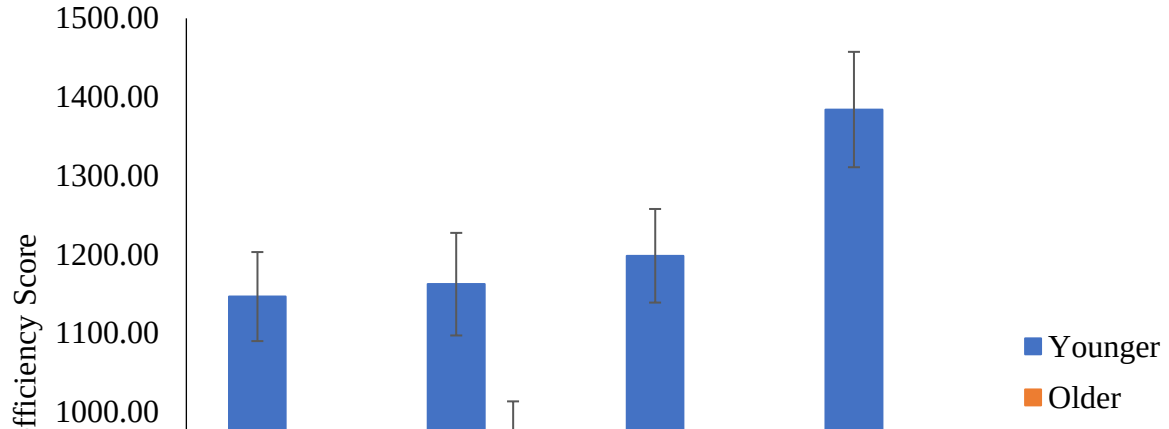


Table 3

Pearson Correlations between each of the four image categories, age (in months), and inhibitory control

	Day/Night Score	Age (in months)
Animal w/Face vs. Object w/o Face	-.133	-.570***
Animal w/Face vs. Object w/Face	.032	-.324
Animal w/o Face vs. Object w/o Face	-.177	-.525**
Animal w/o Face vs. Object w/Face	-.056	-.571***
Day/Night Score	--	.370*

*** p < .001, ** p < .01, * p < .05

6.3 Performance, age, and inhibitory control

We again wanted to examine the extent to which age and inhibitory control played a role in performance on the Catch the Animal Task. Table 3 provides a summary of the correlational analyses conducted between each image combination, age (in months), and performance on the Day/Night Task (M = 69.7% incorrect). Once again, age was significantly correlated with inhibitory control (r = .370, p = .048). Analyses also revealed significant relationships between age and performance on all four of the image groups except for the pair *animals with faces versus objects with faces*.

It is entirely possible that this general trend was due to demand characteristics in the design of the task; in looking at performance in the two age groups, inefficiency scores were overall much lower for the younger children, which suggests that it may have been generally more difficult to complete. Moreover, in contrast to results from experiment 4, here performance on the Day/Night Task was not significantly correlated with performance on any of the four image combinations. This suggests that our Catch the Animal Task did not significantly recruit inhibitory control, at least as measured by the Day/Night Task. Ultimately, however, the most plausible explanation for the lack of correlations is the unusually low performance we again observed on the Day/Night Task; Gerstadt, Hong, and Diamond (1994) reported error rates at 21.9-13.1% for children between the ages of five and six, while here we found an average rate of 69.7% for our sample with a median age of 63.4 months.

7. General Discussion

In conducting experiments 4 and 5, our primary goal was to replicate our findings from chapter 2 (experiments 1 and 2) in a younger population. As with our adult participants, here we predicted that children would exhibit an advantage for detecting animate agents over inanimate objects. While the design of experiment 5 did not enable us to directly test this prediction, results from experiment 4 supported it, as children exhibited overall better performance when categorizing animals, compared to objects.

In addition to evidence for an animate advantage, we had also predicted that facial features would influence superordinate-level categorization, such that the presence of a face would render animals easier, and objects more difficult, to correctly categorize. We observed a robust demonstration of this in experiment 4, as children found it both easier to categorize animals with faces compared to objects with faces, and objects without faces compared to objects with faces. The fact that we found a difference between object conditions here further supports the influence of facial features in young children.

Results from experiment 5 were somewhat more difficult to interpret. In presenting animal and object images simultaneously, we were hypothetically in a better position to observe the differential effects of facial information on either category. We had predicted that animals would be easier to identify when they contained visible facial features, while objects with facial features would cause an interference effect of sorts. The key combination of interest in this experiment was that of the *animals without faces versus objects with faces*; in this case, we anticipated that both the lack of facial features in the animal, and the presence of facial features in the object, would decrease performance. Our results largely confirm that this was indeed the most difficult combination to respond to. However, while we also found a general linear increase in difficulty as a function of image combination, our prediction that

the easiest combination would be that of *animals with faces versus objects without faces* was not confirmed. Unfortunately, we found no performance differences between this pair and either of the other two pairs of images (i.e., *animals without faces versus objects without faces*, and *animals with faces versus objects with faces*). While we are still encouraged by the comparative difficulty on our key combination of interest, we are less certain as to why these differences did not appear in the other three pairs. It is possible that such differences would have emerged with a larger sample size. Alternatively, perhaps the use of competing pairs of images is not the ideal method for measuring the differential effect of facial features in animals and objects. In the future, it may do well to take a step back and attempt a more standard version of the Animacy Categorization Task with this age group, as it is possible that comparing two images causes participants to look for differences between them, rather than focus on the configural information in each. Presenting single images may thus present a better way of addressing this question.

In terms of age effects, we had predicted both a general increase in performance as a function of age, and an overall consistency in the pattern of performance across image conditions. In experiment 4, we found that while performance was not significantly correlated with a continuous increase in age, there were robust differences between the older and younger half of children. Both groups demonstrated more difficulty in both the objects with faces and animals without faces conditions, but the effect was decidedly more pronounced in the younger group. Similarly, results from experiment 5 indicate that performance differences across image combinations were entirely driven by the younger group; even though overall performance was lower compared to the older group, only the younger children demonstrated a greater level of difficulty in our key image combination.

Taken altogether, our results lend support to the notion that explicit superordinate-level categorization abilities improve with age. It is possible that such improvement reflects a significant, qualitative change in how children distinguish between animates and inanimates (e.g., Carey, 1985). Although our intention was not to rule this out as a possibility, we had predicted that inhibitory control might be at play in conditions in which children would need to suppress an intuitive response in favor of a correct one. Under this view, intuitive, core knowledge concepts can be overridden in contexts that require the expression of acquired knowledge (e.g., Gelman, 1990); this would potentially implicate inhibitory control as a means of suppressing an initial, default response. We had predicted this would occur specifically when categorizing objects with faces (experiment 4), and when choosing the animal in the *animal without face versus object with face* image pair (experiment 5). However, contrary to our predictions, in experiment 4 we found that inhibition was correlated with *more* categories than objects with faces, while in experiment 5 we found that it was not correlated with performance on *any* of the image pairs.

Ultimately, the results as they related to inhibitory control are difficult to fit into a coherent framework. A likely explanation is that performance on the Day/Night Task was simply too low to produce any meaningful relationships between the other tasks. Alternatively, it is possible that the Day/Night Task is not an ideal measure of inhibitory control, at least with regards to the two animacy tasks presented here. There exists some evidence to suggest that error rates on this task can be negatively skewed by the fact that an incorrect, default response on one trial is a correct response on another; correcting for this by adjusting the time between trials (Diamond, Kirkham, & Amso, 2002) or by using non-overlapping sets of images (Montgomery, Anderson, & Uhl, 2008) can increase performance,

but we made no such modifications here (for a review of methodological concerns with the Day/Night Task see Montgomery & Koeltzow, 2010). And while recent studies have implicated inhibitory control as a factor in judgments of animacy (Zaitchik, Iqbal, & Carey, 2013), they used an arguably more sensitive battery of inhibitory control tasks. It may thus be the case that inhibitory control is indeed recruited by our two animacy tasks, but that we selected an inappropriate means of measuring it. Despite this, with minor modifications to our design we feel that we can continue to examine the role of inhibitory control in superordinate-level categorization and judgments of animacy. Moreover, we are encouraged by the overall findings from this set of experiments, which indicate that preschool-aged children are generally better at categorizing animals compared to objects, and that facial features can act as a cue of animacy (or of membership in the "animal" category) in the absence of explicit motion cues. Our results are consistent with those obtained in similar studies on adult participants, and suggest that the animacy detection system remains sensitive to specific cues throughout the lifespan.

CHAPTER 5

General discussion and future directions

1. Introduction

Humans appear to be especially good at rapidly detecting animals in their surroundings. This ability likely reflects an evolved solution to a number of adaptive problems, the most basic of which entails a decision of where to orient one's attention at a given moment in time (e.g., New et al., 2007; New et al., 2010; Thorpe et al., 2001). Animals – or animate agents more generally – are by nature less predictable than inanimate objects, and should be detected quickly and monitored closely if one wishes to predict their likely next course of action. There should also be an adaptive incentive to *over-detect* animate agents in one's surroundings, as the potential cost of a failure to detect (i.e., a false negative) far outweighs the cost of mistaken detection (i.e., a false positive). To the extent that the mind contains a specialized system for the rapid, automatic detection of animate agents, it should thus be more sensitive to specific inputs, or *cues*, that are functionally associated with animacy.

There exists a wealth of research examining the role of motion cues in animacy detection. The mind appears to place certain constraints on the type of motion that will be interpreted as animate: self-propulsion, which indicates an internal source of energy and the subsequent ability to move without being contacted (e.g., Leslie, 1994; Premack, 1990), and indications of the capacity to move in pursuit of goals, such as the selection of a rational pathway (e.g., Csibra et al., 2003), the maintenance of a goal despite changes in the environment (e.g., Gergeley et al., 1995), or contingent reactivity with another animate agent (e.g., Johnson, Slaughter, & Carey, 1998). On the other hand, the mind seems to allow for significant variation in appearance as long as these conditions are met. Heider and Simmel (1944) were among the first to demonstrate that simple shapes will be interpreted as animate

if they exhibit self-propelled, goal-directed motion, and this effect has been replicated countless times since then (for reviews see Scholl & Tremoulet, 2000; Opfer & Gelman, 2011).

Through the course of this dissertation I have attempted to demonstrate that the well-documented tendency to quickly and automatically detect animate agents in one's surroundings can be cued by the mere presence of facial features in the absence of motion. The capacity for self-propelled, goal-directed motion necessitates some form of perceptual feedback from the environment. Faces, which contain a wealth of sensory systems, should thus provide a robust cue of the capacity for such motion. Indeed, humans exhibit a preferential attention to faces from birth (e.g., Morton & Johnson, 1991), and appear to use facial features – most especially the direction of an agent's gaze – to infer their likely next course of action (e.g., Willen, Hood, & Driver, 1997). In light of this, it seems plausible that the possession of features which exhibit a face-like configuration could also quickly and automatically activate the animacy detection system – crucially, even in cases where such configurations appear "out of context," as a part of inanimate objects.

The images used in the series experiments described here were purposely chosen to examine facial features in isolation from other possible morphological cues. This was done by providing two sets of animals which varied only in terms of the visibility of the face, and by taking advantage of an instance where facial features are presented "out of context" – in inanimate objects. Across all of these experiments, I had predicted that: 1) performance would generally be better when responding to animals, compared to objects, and 2) the presence of facial features would aid in making correct judgments of animacy, and would

hinder correct judgments of inanimacy. Below I will summarize the findings from each experiment.

2. Facial features as a cue of animacy

Chapter 2 introduced a novel method for measuring the influence of facial features in animacy detection – The Animacy/Inanimacy Judgment Tasks, and the Animacy Categorization Task. In experiment 1a, participants were asked to make yes/no judgments of animacy under time pressure. Experiment 1b served as a mirror to this experiment, which attempted to account for a possible endorsement bias by requiring participants to make judgments of *inanimacy* (e.g., Knowles & Condon, 1999). Other than a general increase in response time, we found that the predicted pattern of responses still held. This was also the case for experiment 2, in which several changes were made to both the image sets and the design of the trials. The fact that responses were largely consistent between experiments 1 and 2 indicates that our use of unmatched sets of images in experiments 1a and 1b was warranted, as facial features had the predicted effect regardless of familiarity (in the animals) or differences in visual background noise (in the objects). Moreover, the consistent pattern of responses across these experiments indicates that facial features can be influential both when making judgments of animacy (or inanimacy) and when categorizing entities into animal and objects groups.

By and large, we were able to provide a robust demonstration of the predicted effect, even when controlling for a possible endorsement bias, using sets of animals and objects that were not well-matched in terms of familiarity and visual background noise, and altering the nature of the task from a yes/no judgment of animate or inanimate to categorization into animal and object groups. Across all three experiments, participants made faster and more

accurate responses when viewing animals with visible facial features, and slower and less accurate responses when viewing objects with visible facial features.

3. The inversion effect and animacy detection

Chapter 3 examined the role of inversion on superordinate-level categorization. The so-called inversion effect is a well-documented decrease in the ability to recognize faces when they are presented in an inverted orientation (Yin, 1969). This is thought to be due to a disruption in our encoding of faces in memory; when upright we attend to the minor variations between different features, but when inverted, we are unable to do this, and pay more attention to each feature in isolation (Diamond & Carey, 1986). It is the relational properties of facial features that allows us to individuate them, but an important question concerns the degree to which inversion also disrupts our ability to *detect* faces as such. Research from neuroimaging studies indicates that inversion does not significantly decrease activation in face detection areas (e.g., Kanwisher, Tong, & Nakayama, 1998), and that it delays, but does not entirely inhibit, face perception (e.g., Sekuler et al., 2004). This suggests that the face perception system allows for some degree of variance in orientation; the question is, to what extent are changes in orientation allowed as input to the animacy detection system?

In chapter 3 I attempted to further address this question by examining the extent to which inverted faces are used as input to the animacy detection system, which may be biased towards over-detection not only in the presence of "out of context" facial information (i.e., faces in objects), but also when presented in an inverted orientation. If this were indeed the case, one could predict that inversion would have little to no effect on categorization; objects with faces would be just as difficult to categorize when upright or inverted, and animals with

faces would be just as easy. Alternatively, inverted faces might have a similar effect to the objects with scrambled faces and the animal backs in experiment 2. If this were found to be the case, it would indicate that the animacy detection system does not include inverted faces as acceptable input.

While we again found evidence for the animate advantage in experiment 3, our other results were considerably less conclusive. Inverted animals were generally more difficult to categorize than their upright counterparts, which replicated findings from similar studies that used inversion to control for low-level visual effects (e.g., New et al., 2007, Ro, Russel, & Lavie, 2001). This suggests that upright orientation is an important cue for the animacy detection system. However, in the case of objects with faces, we found that while they were generally more difficult to categorize than either of the two sets of animals, there was no difference between performance on upright and inverted orientations. On the surface, this appeared to provide evidence in favor of an animacy detection system that allows for variance in face orientation. However, because we inverted the entire image rather than just the facial features, we could not rule out the possibility that the inverted objects were difficult to categorize due to expertise effects; prior research has indicated that experimentally trained or self-declared experts in differentiating specific objects exhibit the same degree of difficulty in recognizing inverted objects as inverted faces (Diamond & Carey, 1986; Gauthier & Tarr, 2002), and as our objects were likely to be highly familiar to participants, this might have been a factor in our study as well. However, while the results from experiment 3 were fairly inconclusive, we feel that this is still a question worth pursuing, and that it would be easily pursuable with a few modifications to the existing design.

4. The role of facial features in childhood animacy detection

Prior research has indicated that pre-verbal infants preferentially attend to both self-propelled motion and morphological cues, and use those cues to make complex inferences regarding both the animacy and intentionality of entities (for a comprehensive review see Opfer & Gelman, 2011). This extends into childhood, as preschool-aged children use motion cues as a defining characteristic when explicitly categorizing animate agents (e.g., Massey & Gelman, 1988; Rhodes & Gelman, 2009), and to such a degree that they are prone to making errors when categorizing animates that do not exhibit self-propelled motion or inanimates that do (e.g., Margett & Witherington, 2011). While there is some evidence that children also preferentially attend to faces (e.g. Taylor et al., 2001), it is not clear if they place the same weight on facial features in their judgments of animacy.

The primary aim of the experiments described in chapter 4 was to demonstrate a similar influence of facial features between children and adults. As previous studies have shown that children improve in their categorization abilities with age (e.g., Johnson, Mervis & Boster, 1992), we hoped to replicate this effect here. However, we also hoped to provide evidence that facial features, like motion cues, activate a core domain of knowledge that is specialized for the detection of animate agents, and that remains relatively unchanged throughout the lifespan (e.g., Gelman, 1990; Leslie, 1994). Because of this we predicted that the overall pattern of responses would be maintained despite improvements in age. More specifically, we anticipated that there would be a general age-related improvement across the four types of images, but that even older children would still commit the most errors when categorizing objects with faces and animals without faces. Moreover, we reasoned that if these tasks were indeed tapping into a core knowledge system, improvements in performance would be at least partially related to improvements in inhibitory control, or the ability to

suppress a default but incorrect response in favor of a correct one (e.g., Zelazo & Frye, 1997). As such, we anticipated that inhibition would only be related to performance on images of objects with faces.

In chapter 4, two experiments were conducted to examine the influence of facial features on superordinate-level categorization in children between the ages of three and six years of age. Experiment 4 introduced the Animacy Card Sort Task, in which children were asked to sort images (a subset of those used in experiments 2 and 3) into animal and object boxes. Here we predicted a similar pattern of results to the adult participants in previous chapters; evidence for an advantage in correctly categorizing animals, compared to objects, and a greater rate of errors when sorting objects with faces and animals without faces. Although evidence for an animate advantage was somewhat influenced by the position of the boxes (a difference only emerged when the animal box was on the right side, in which case children made fewer errors compared to objects), the results from experiment 4 were largely consistent with our second prediction, that facial features would differentially influence superordinate-level categorization.

In experiment 5, we presented a computerized version of the Animacy Categorization Task (introduced in experiment 2), which was adapted to be more engaging for younger children. In the Catch the Animal Task, children viewed two images side-by-side and were asked to "catch the animal" in each. Here we anticipated that our predicted effect would manifest as a difficulty with one specific pair of images – *animals without faces* (which would be more difficult to correctly select because of a lack of visible facial features) *versus objects with faces* (which would be more difficult to inhibit because of the presence of visible facial features). While we indeed found that this was the case, another of our predictions –

that the *animals with faces versus objects without faces* would be the easiest combination – was not confirmed.

In terms of age effects, in both experiments we found that younger children exhibited our predicted pattern of performance, but that the difference was attenuated in the older group. In experiment 4, objects with faces and animals without faces were still relatively more difficult for the older group of children, which suggested that facial features may continue to have an effect even as overall categorization ability improves. However, in experiment 5, no differences in performance emerged for the older group of children; the observed effects were entirely driven by the younger group. As for the role of inhibition, we found that in experiment 4 it was related to *more* categories than just performance on the objects with faces condition, while in experiment 5 it was not related to *any* combination of images. We were extremely wary about attaching too much significance to these results, as overall performance on our measure of inhibition – the Day/Night Task (Gerstadt, Hong, & Diamond, 1994) – was unusually low. As this task has been criticized for inherent demand characteristics, in future studies we hope to implement multiple tasks which provide more sensitive measures of inhibition (e.g. spatial inhibition measures such as the Simon Task; for a review see Lu & Proctor, 1995).

Though we were able to demonstrate that facial features can influence superordinate-level categorization in preschool-aged children, our conclusions with regards to age and inhibitory control are decidedly less clear-cut. Only experiment 4 provided preliminary evidence for age-related improvements, while neither experiment produced interpretable patterns for inhibitory control. To the extent that the predicted effects did not emerge, we believe that it was most likely due to demand characteristics in our animacy tasks. This is

especially true for experiment 5, in which a performance difference was revealed only in the younger group of children, and then only in terms of one of our predictions. It is possible that presenting two images simultaneously engages processes which are more dependent on feature-by-feature comparisons than configural information. In line with this possibility, a plausible next step would be to implement a more standard version of the Animacy Categorization Task on children in this age range. Still, we are encouraged by the results from experiment 4, and feel that this remains a viable method of studying cues for the animacy detection system, with a few modifications.

5. Future Directions

In this dissertation, I have occasionally touched on the idea that animacy detection may exist as a prerequisite system for making more complex inferences about humans in particular. There exists some evidence that the detection of animate agents and the application of more complex mental states may be dissociable. New et al. (2010) for example, demonstrated that individuals on the autism spectrum are able to distinguish between animate agents and inanimate objects, despite well-documented deficits in the attribution of mental states to the former (e.g., Castelli, Frith, Happé, & Frith, 2002). Developmental studies also hint at this, as young children are often reluctant to group humans together with other animate agents (e.g., Carey, 1985). Over and above classification as animate agents, it seems that the mind affords humans a special status, one which may be based on the attribution of more complex mental states that underlie social interactions.

The adaptive benefits for the quick, automatic, and occasionally mistaken detection of animate agents in one's surroundings are difficult to overstate. I would argue here that the potential benefits of identifying opportunities for social interaction (and the potential costs of

failing to identify them) are equally robust, if less subject to time pressure. It seems plausible, at least from a theoretical standpoint, that humans would have evolved a sensitivity for reasoning about social interactions – an important aspect of which would be to receive feedback regarding what a social agent may do next. What cues might the mind use to make such predictions? One likely candidate is facial expressions of emotion, which humans begin to express from infancy, and which are expressed in the same way across a vast array of different cultures (for an early review see Ekman & Oster, 1979). Some have argued that emotional expressions evolved to facilitate communication, as they essentially signal one's social motivations to others and can thus lead to a reasonable prediction of one's likely next course of action (e.g., Fridlund, 1994; 1997). It may thus be the case that, beyond using the mere presence of facial features as a cue of animacy, humans are especially sensitive to the *emotional information* conveyed by faces.

As a first step in addressing this possibility, one could examine the extent to which the emotional information conveyed in faces interferes with other, arguably less relevant attributions, such as those which convey physical properties (e.g., shape, color). Preliminary research from our own laboratory, which has extended the animacy experiments described here to emotion attribution, has tested participants on the types of attributions they tend to make towards objects that contain visible facial features. Our results thus far have indicated that participants find it difficult to inhibit an emotional attribution (e.g., happy, sad, etc.) in favor of a physical attribution (e.g., round, white, etc.) when viewing objects with faces compared to scrambled counterparts. We have also found that performance on this task correlates with a self-report measure of individual differences in anthropomorphism, or the tendency to attribute uniquely human characteristics to non-human entities (Epley, Waytz, &

Cacioppo, 2010) This is consistent with claims that the degree to which one attends to emotional expressions may be subject to variance between individuals depending on different degrees of motivation for social interaction (e.g., Epley, Waytz, Akalis, & Cacioppo, 2008). These preliminary results are encouraging, and we feel that the study of human sensitivity to expression of emotions provides a rich area for future exploration.

SUPPLEMENTARY MATERIALS FOR CHAPTER 2

Images used:

Experiments 1a and 1b			
Animals w/Face		Animals w/o Face	
Bear	Frog	Anemone	Moth
Bird	Horse	Ant	Octopus
Bunny	Lion	Bee	Pill Bug
Cat	Lizard	Butterfly	Ray
Chimpanzee	Llama	Caterpillar	Scorpion
Cow	Mouse	Clam	Sea Slug
Dog	Panda	Earthworm	Seahorse
Duck	Pig	Flatworm	Snail
Elephant	Raccoon	Jellyfish	Squid
Fish	Turtle	Ladybug	Starfish
Objects w/Face		Objects w/o Face	
Alarm Clock (sad)	Concrete (happy)	Ball	Guitar
Backpack (angry)	Drain (sad)	Bicycle	Hammer
Bathtub (sad)	Drawer (afraid)	Bottle	Hat
Brown Purse (sad)	Kayak (angry)	Bowl	Lamp
Cake (angry)	Outlets (angry)	Chair	Pencil
Camera (afraid)	Peppers (afraid)	Comb	Penny
Car (afraid)	Pink Purse (happy)	Couch	Rock
Chain (happy)	Plastic (sad)	Crayon	Spoon
Chairs (happy)	Plastic Bag (afraid)	Dice	Tea Pot
Coffee (happy)	Tree (angry)	Glasses	Toothbrush

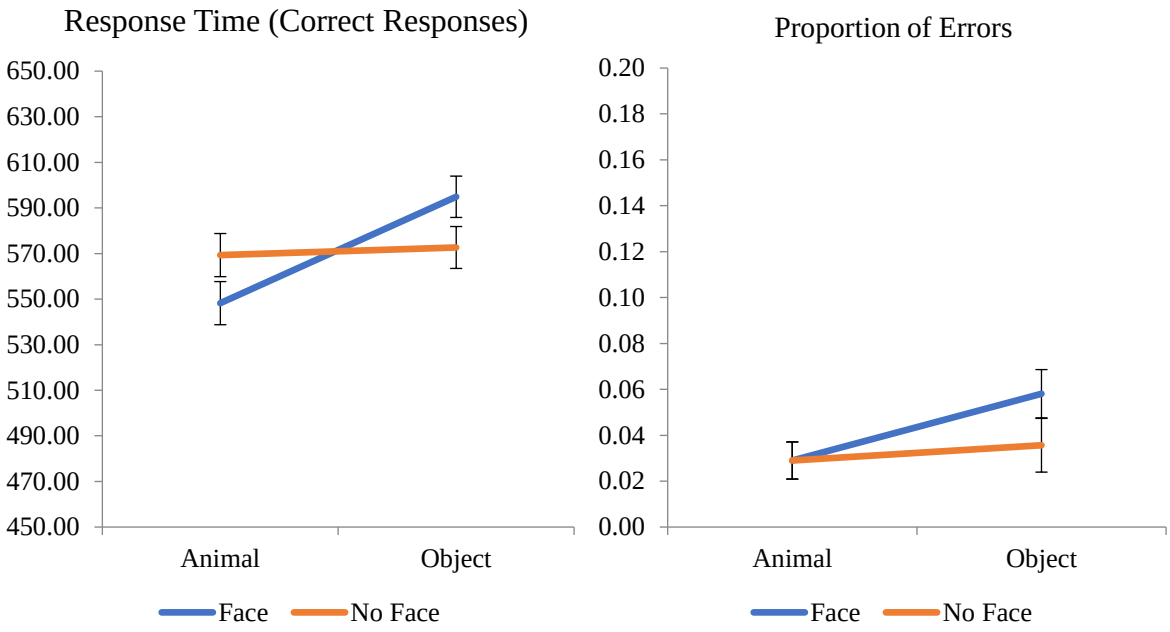
Pearson Correlations for Image Conditions

		Experiment 1a			
		Animals		Objects	
		w/Faces	w/o Faces	w/Faces	w/o Faces
Animals	w/Faces	--	.867***	.666***	.773***
	w/o Faces	--	--	.643***	.826***
Objects	w/Faces	--	--	--	.736***
	w/o Faces	--	--	--	--

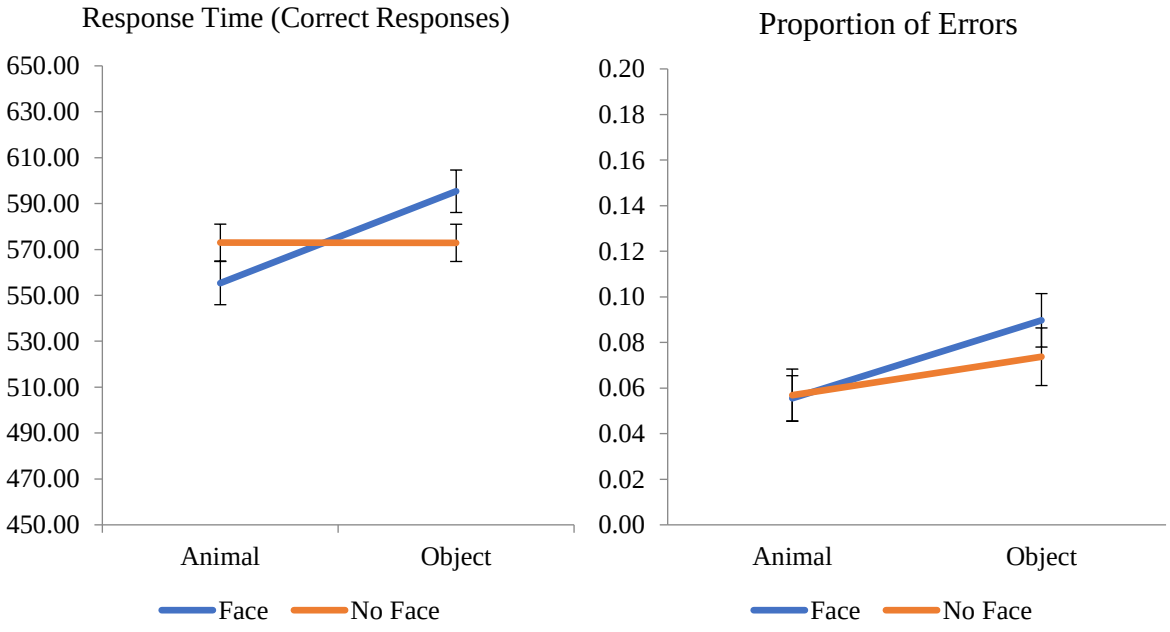
		Experiment 1b			
		Animals		Objects	
		w/Faces	w/o Faces	w/Faces	w/o Faces
Animals	w/Faces	--	.761***	.798***	.863***
	w/o Faces	--	--	.760***	.716***
Objects	w/Faces	--	--	--	.796***
	w/o Faces	--	--	--	--

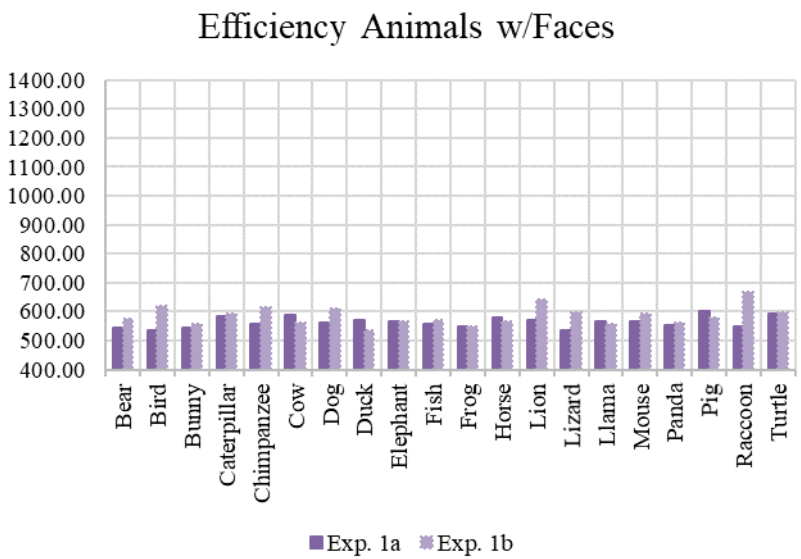
*** $p < .001$

Experiment 1a – Animacy Judgment Task



Experiment 1b – Inanimacy Judgment Task




Efficiency Animals w/Faces
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
Bear
Bird
Bunny
Caterpillar
Chimpanzee
Cow
Dog
Duck
Elephant
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Horse
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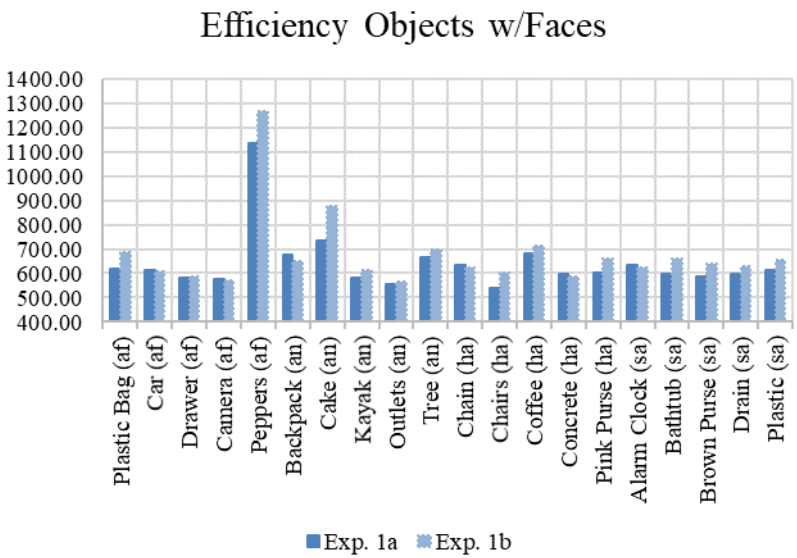
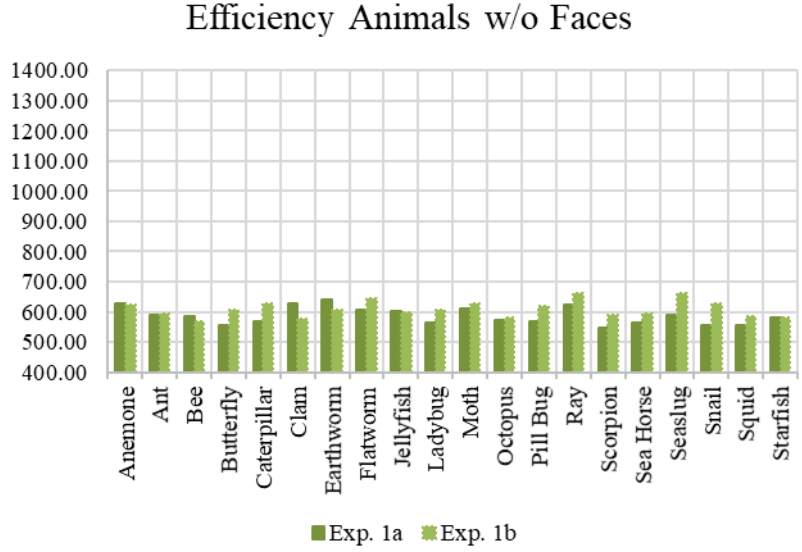
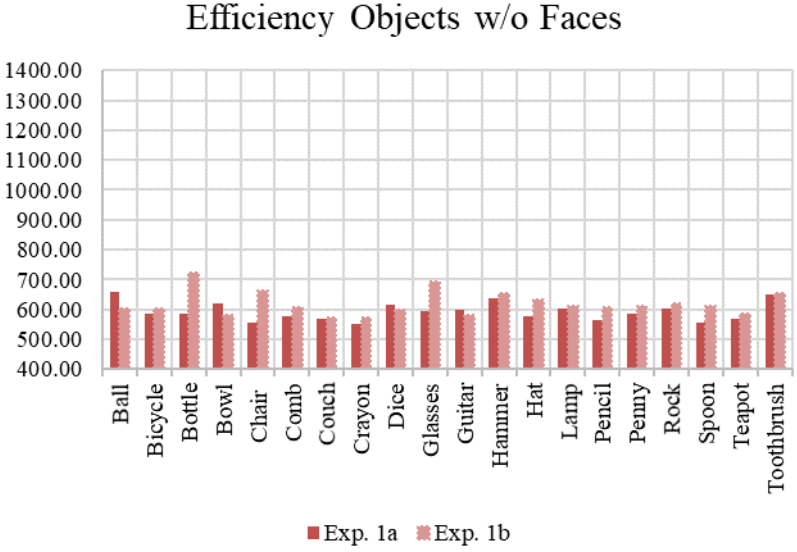
Mouse
Panda
Pig
Raccoon
Turtle
Exp. 1a
Exp. 1b


Efficiency Objects w/Faces
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
Plastic Bag (af)
Car (af)
Drawer (af)
Camera (af)
Peppers (af)
Backpack (an)
Cake (an)
Kayak (an)
Outlets (an)
Tree (an)
Chain (ha)
Chairs (ha)
Coffee (ha)
Concrete (ha)
Pink Purse (ha)
Alarm Clock (sa)
Bathtub (sa)
Brown Purse (sa)
Drain (sa)
Plastic (sa)
Exp. 1a
Exp. 1b


Efficiency Animals w/o Faces
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
Anemone
Ant
Bee
Butterfly
Caterpillar
Clam
Earthworm
Flatworm
Jellyfish
Ladybug
Moth
Octopus
Pill Bug
Ray
Scorpion
Sea Horse
Seaslug
Snail
Squid
Starfish
Exp. 1a
Exp. 1b


Efficiency Objects w/o Faces
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
Ball
Bicycle
Bottle
Bowl
Chair
Comb
Couch
Crayon
Dice
Glasses
Guitar
Hammer
Hat
Lamp
Pencil
Penny
Rock
Spoon
Teapot
Toothbrush
Exp. 1a
Exp. 1b

Images used:

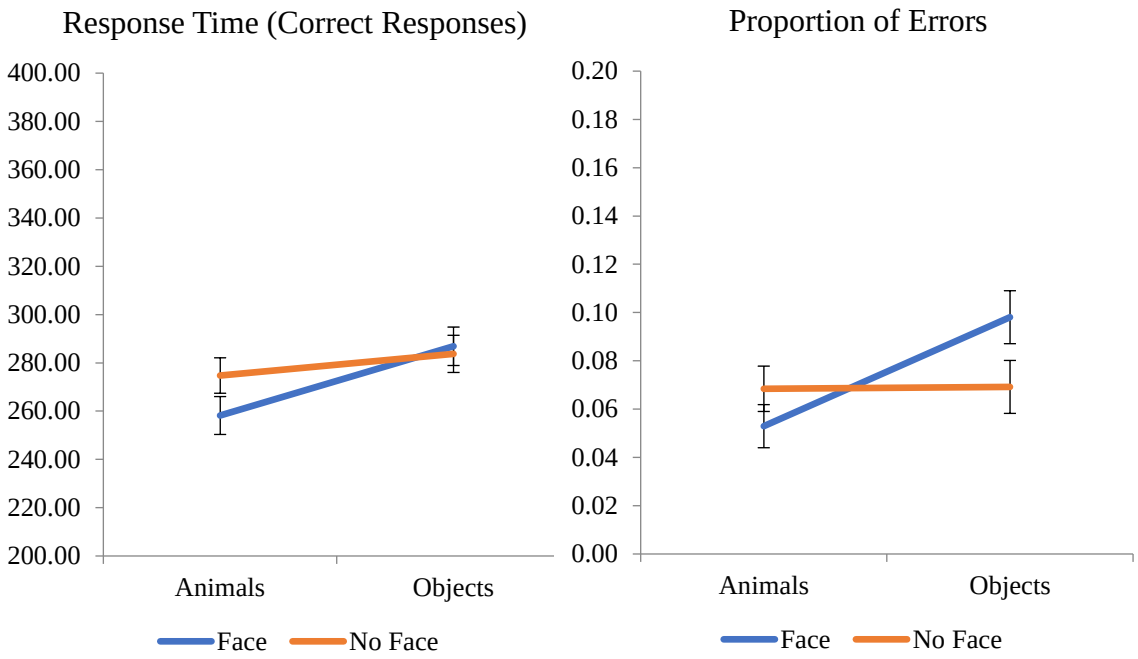
Experiment 2			
Animals		Objects	
Antelope	*Meerkat*	Alarm Clock (sad)	Coffee (happy)
Armadillo	*Okapi*	Backpack (angry)	*Coffee Lid (happy)*
Camel	*Pangolin*	Bathtub (sad)	Drawer (afraid)
Capybara	Raccoon	*BBQ (angry)*	Kayak (angry)
Echidna	*Red Panda*	Brown Purse (sad)	*Laptop Case (angry)*
Frog	*Seagull*	Camera (afraid)	Pink Purse (happy)
Gorilla	*Sloth*	*Can Lid (sad)*	Plastic Bag (afraid)
Hedgehog	*Tapir*	Chain (happy)	*Slippers (angry)*
Lion	Turtle	Chairs (happy)	*Teapot (afraid)*
Llama	*Wombat*	*Clock Dials (sad)*	*Tower (afraid)*

Pearson Correlations for Image Conditions (*** $p < .001$)

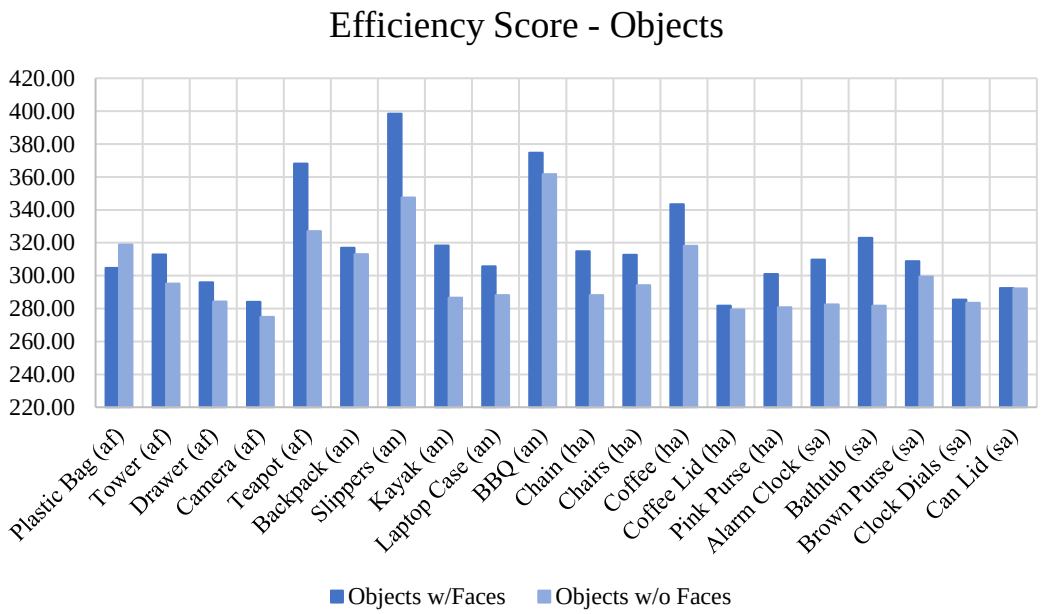
		Experiment 2			
		Animals		Objects	
		w/Faces	w/o Faces	w/Faces	w/o Faces
Animals	w/Faces	--	.848***	.698***	.808***
	w/o Faces	--	--	.787***	.764***
Objects	w/Faces	--	--	--	.645***
	w/o Faces	--	--	--	--

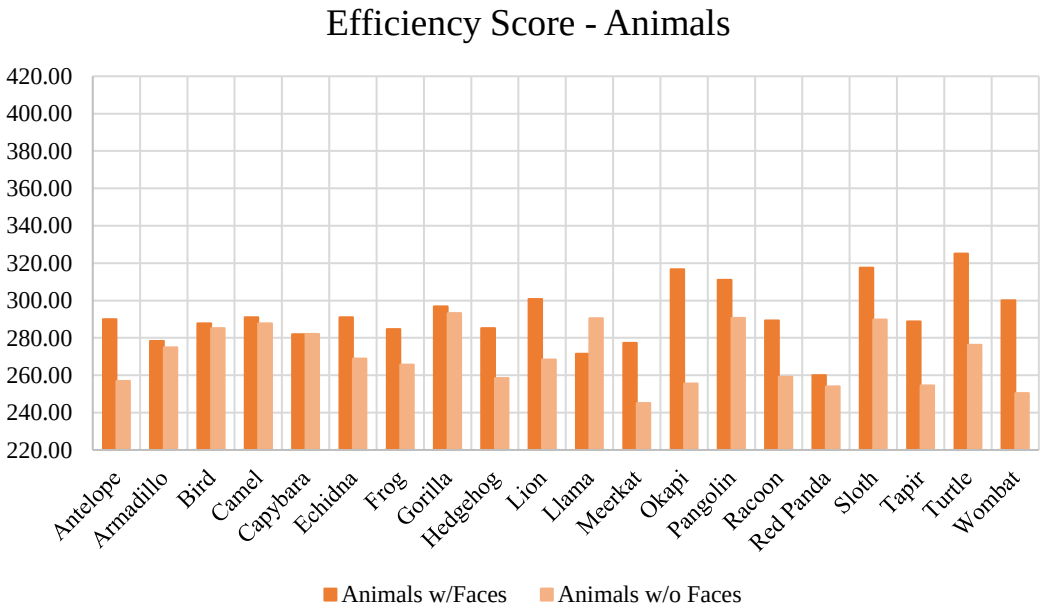
*** $p < .001$

Experiment 2 – Animacy Categorization Task



Experiment 2 – Animacy Categorization Task





Images used:

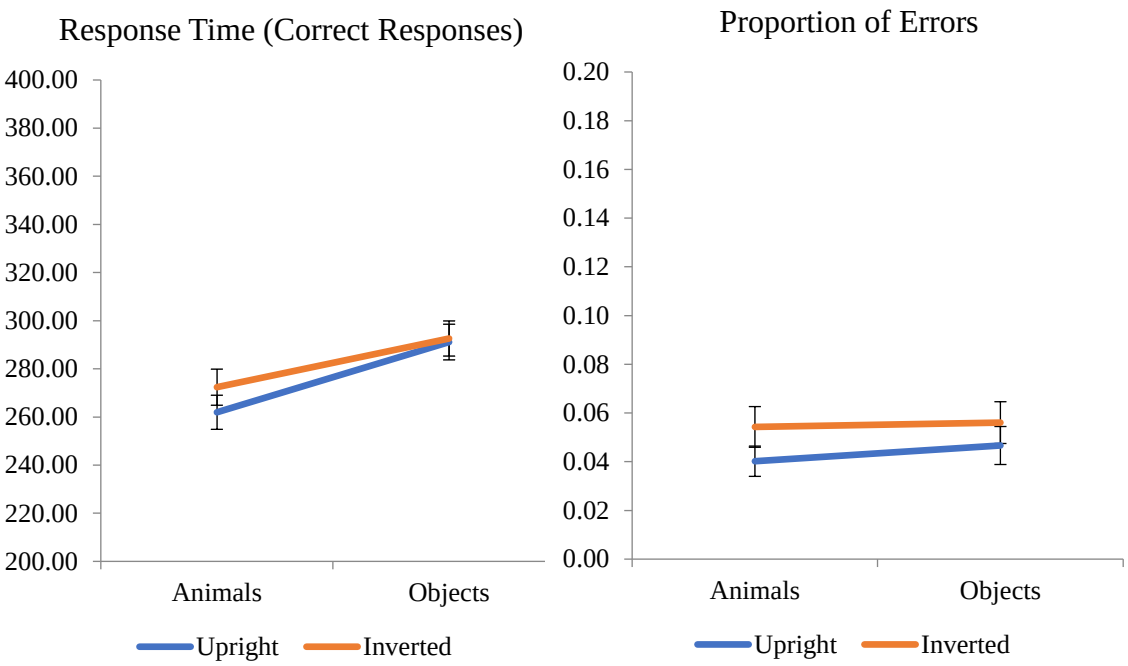
Experiment 3			
Animals		Objects	
Antelope	*Meerkat*	Alarm Clock (sad)	Coffee (happy)
Armadillo	*Okapi*	Backpack (angry)	*Coffee Lid (happy)*
Camel	*Pangolin*	Bathtub (sad)	Drawer (afraid)
Capybara	Raccoon	*BBQ (angry)*	Kayak (angry)
Echidna	*Red Panda*	Brown Purse (sad)	*Laptop Case (angry)*
Frog	*Seagull*	Camera (afraid)	Pink Purse (happy)
Gorilla	*Sloth*	*Can Lid (sad)*	Plastic Bag (afraid)
Hedgehog	*Tapir*	Chain (happy)	*Slippers (angry)*
Lion	Turtle	Chairs (happy)	*Teapot (afraid)*
Llama	*Wombat*	*Clock Dials (sad)*	*Tower (afraid)*

Pearson Correlations for Image Conditions (*** $p < .001$)

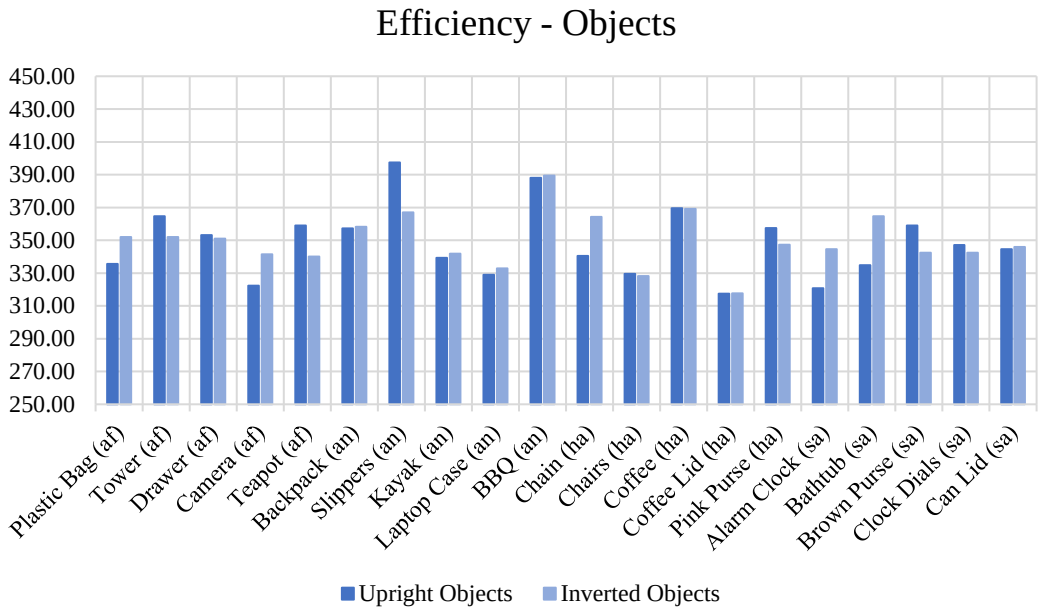
		Experiment 3			
		Animals		Objects	
		Upright	Inverted	Upright	Inverted
Animals	Upright	--	.922***	.870***	.799***
	Inverted	--	--	.865***	.818***
Objects	Upright	--	--	--	.874***
	Inverted	--	--	--	--

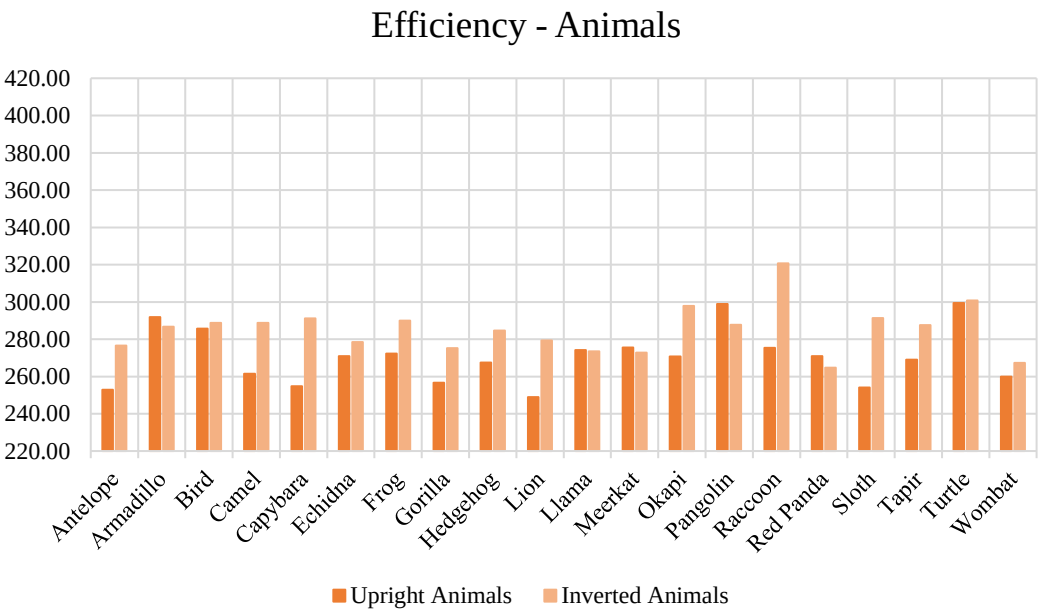
*** p < .001

Experiment 3 – Animacy Categorization Task (Upright vs. Inverted)



Experiment 3 – Animacy Categorization Task (Upright vs. Inverted)



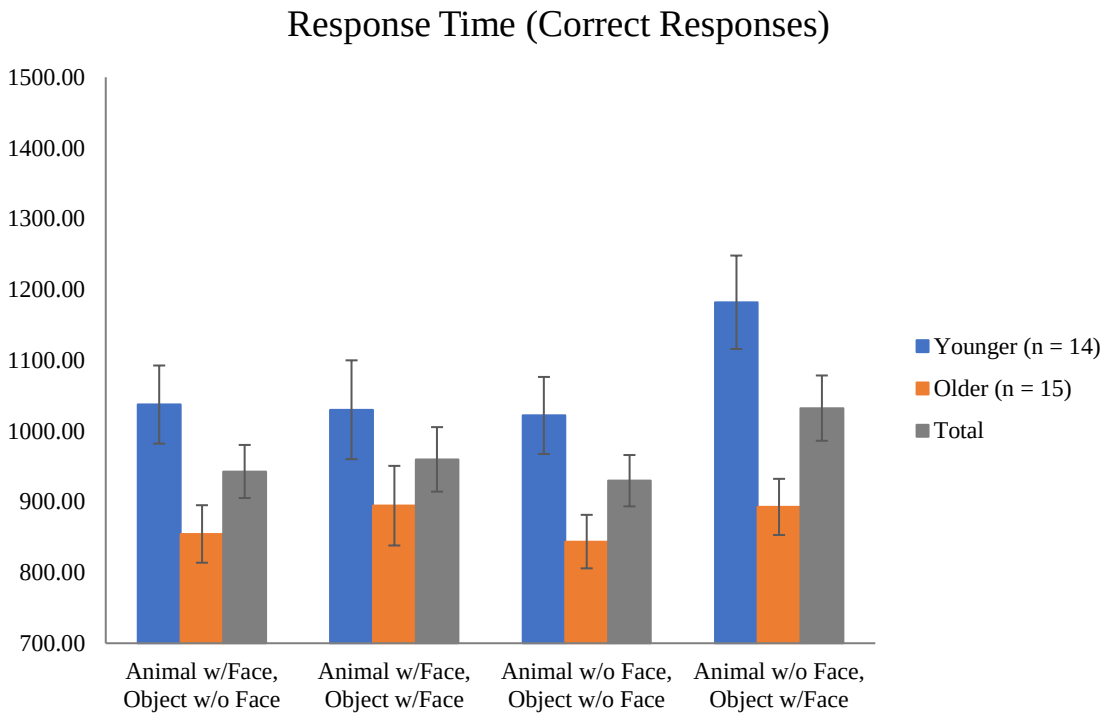


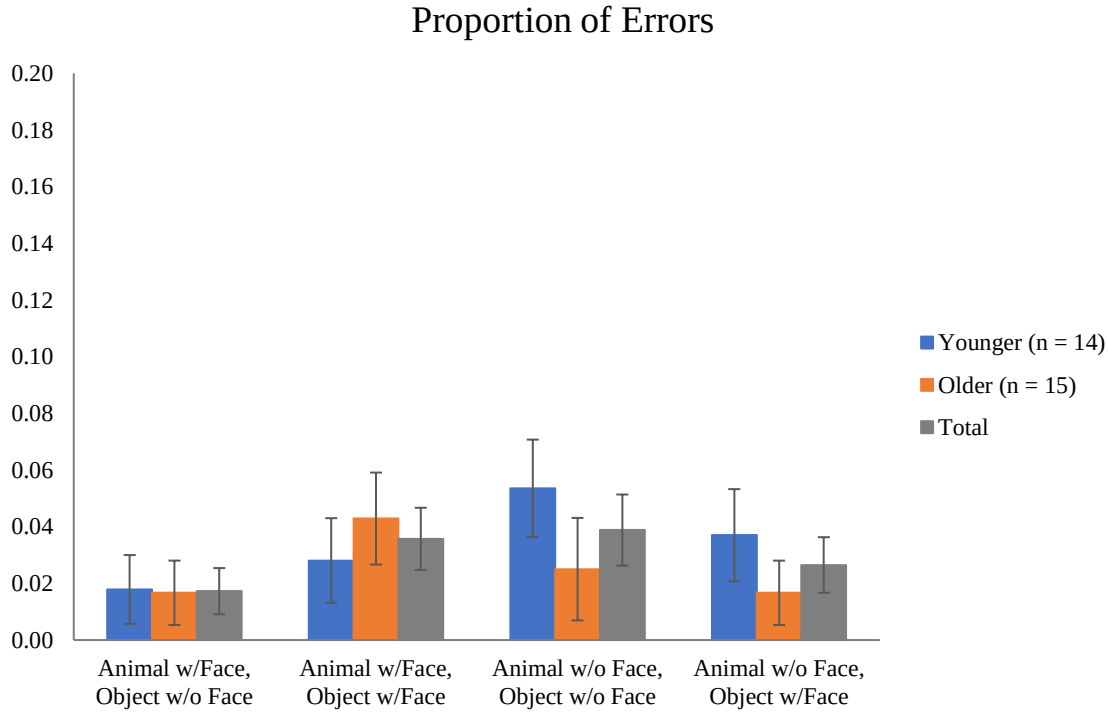
SUPPLEMENTARY MATERIALS FOR CHAPTER 4

Images used:

Experiments 4-5			
Animals w/Face		Animals w/o Face	
Camel	Red Panda	Armadillo	Pangolin
Frog	Seagull	Capybara	Raccoon
Hedgehog	*Sloth*	Echidna	Tapir
Lion	Wombat	*Iguana*	Turtle
Objects w/Face		Objects w/o Face	
Alarm Clock (sad)	Camera (afraid)	Can Lid	*Hamper*
BBQ (angry)	Coffee Lid (happy)	*Chair*	Plastic Bag
Bike Chair (afraid)	Laptop Case (angry)	Chairs	Teapot
Brown Purse (sad)	Pink Purse (happy)	*Guitar*	Tower

Experiment 5 – The Catch the Animal Task





Animacy Card Sort Task

Instructions

Materials

- Two wooden boxes
- Stack of 32 cards

Procedure

Before starting the task:

- Look at the child's scoring sheet to see which category goes on the left/right
- Affix an Animal (w/face) card to one box and an Object (w/o face) card to the other box – these cards will be larger than the regular cards and will have a velcro sticker on the back of them
- Arrange the stack of test cards in the following order:
    - The first two cards in the stack are one of each type of test card (e.g., one Animal [w/face] card and one Object [w/o face] card) – these are marked with a "P" (for "practice") on the back
    - For the rest of the cards, the same type of card should not come up more than twice in a row (i.e., a maximum of two animals or two objects in a row)
- Once it is organized, place the stack face-down next to you on the side furthest from the child (out of their reach)
- Place the two boxes side by side in front of the child, ensuring that they are within reaching distance. Sit beside the child so that you are able to view the display cards on the boxes.

During the task:

- Whenever the child sorts a card, ensure that the card is placed face down in the appropriate box. If necessary, turn the card over before starting the next trial.
- In some cases the child may wish to point to a box instead of sorting the card. If that happens, it's okay for you to place the card in the box they point to.
- The child has until you draw the next card to change their response.
- Avoid using evaluative language (i.e., words or inflection that could lead the child to think they sorted correctly/incorrectly). Keep a neutral tone of voice and avoid words like "Okay" or "Good".
- Once the child is finished, record the total number of correct responses in each of the four image categories on the child's scoring sheet (maximum of 8 correct).

Animacy Card Sort Task
Script

Demonstration phase

"This is the sorting game. In the sorting game, all the *Animals* go here *[pointing to the appropriate box]*, and all the *Objects* go there *[pointing to the appropriate box]*."

"Sometimes in this game you'll see an object that looks like it has a face. But remember that even if it does, it's still an object."

[Show child the Animal card]
"See, here's an *Animal [pick up card and show to child]*. Where does it go?"

- *[If the child takes the card and sorts it correctly, say]*
  "Very good. You know how to play the sorting game."

- *[If they point, say]*
  "Very good. You know how to play the sorting game. Can you help me put this *Animal* one down?"

- *[If the child sorts incorrectly, say]*
  "No, this one's an *Animal*, so it has to go in this box in the sorting game. Can you help me put this *Animal* one down? *[wait for child to place card]* Very good. You know how to play the sorting game."

[Show child the other type of test card]
"Now here's an *Object*. Where does this one go?" *[Follow same procedure as above for responses]*

Test phase

[Select the next test card and show it to the child]
"Now it's your turn. Where does this one go?"

[Regardless of whether the child sorts correctly, say]
"Let's do another one" *OR* "Let's do it again"
[Do NOT provide feedback if card is sorted incorrectly]

[Repeat until deck is sorted. Once completed, say]

"Great, we're all done! You did an awesome job – thank you so much for helping us today! Would you like to pick out a sticker?"

Day/Night Task

Instructions

Materials

- Stack of 16 cards (8 suns, 8 moons)

Procedure

Before starting the task:

- Place two cards – one sun and one moon – face down on the table between you and the child
- Shuffle the remaining 14 cards so that one type of card appears no more than twice in a row (i.e., no more than two suns or two moons in a row)

During the task:

- Holding the deck of cards in one hand, flip each card up from the front so that the picture is facing the child. As soon as the child responds, place each card on the seat next to you and out of the child's sight.
    - Place the card face down if correct, and face up if incorrect
- The test phase of this task is largely non-verbal. You can prompt the child if they get distracted by saying something like "are you ready for the next one?" or "are you paying attention?", but avoid using evaluative language (i.e., words or inflection that could lead the child to think they sorted correctly/incorrectly). Keep a neutral tone of voice and avoid words like "Okay" or "Good".
- Once the child is finished, record the number of correct responses (out of 14) on the child's scoring sheet.

Day/Night Task

Script

Practice phase

"Now we're going to play an opposites game."

[Show child picture of the sun]

"Can you tell me what this is?"

"In this game, whenever I show you a picture of a sun, I want you to say **'night.'**"

[Show child picture of the moon]

"Can you tell me what this is?"

"Whenever I show you a picture of a moon, I want you to say **'day.'**"

"Okay, let's practice!"

[Show child picture of the sun and wait for a response]

- *[If the child does not respond after 5 seconds, repeated the prompt by saying]*
  "Can you tell me what this is?"
- *[If the child responds incorrectly, say]*
  "No, remember – this is an opposites game. So when you see a picture of a sun, you're supposed to say **'night.'** Let's try again." *[Show picture of the sun again]*
- *[If the child responds correctly, say]*
  "Very good, let's try another practice."

[Repeat for picture of the moon. If child responds correctly, say]

"Okay! Now we're going to play the game. Try to respond as soon as you see the picture on the card. Are you ready?"

<u>Test phase</u>

[Keep the cards in a stack, face down on the table between you and the child. Flip each card up away from you and hold it up so the child can see the picture. As soon as the child responds, put the card down in a separate pile on the seat next to you and move on to the next card]

SUPPLEMENTARY MATERIALS – ALL IMAGES

Alarm Clock (Sad) [exp 1,2,3,4,5]


BBQ (Angry) [exp 2,3,4,5]


Backpack (Angry) [exp 1,2,3]


Bathtub (Sad) [exp 1,2,3]

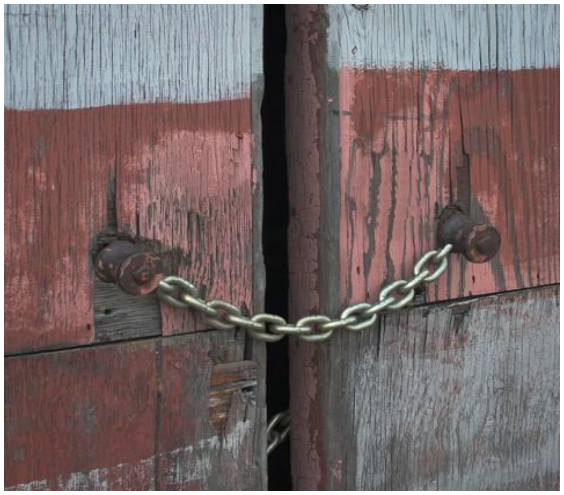

Bike Chair (Afraid) [exp 4,5]


Brown Purse (Sad) [exp 1,2,3,4,5]


Camera (Afraid) [exp 1,2,3,4,5]


Can Lid (Sad) [exp 2,3,4,5]


Car (Afraid) [exp 1]

Chain (Happy) [exp 1,2,3]


Chair (Happy) [exp 4,5]


Chair (Happy) [exp 1,2,3,4,5]

Clock Dials (Sad) [exp 2,3]

Coffee (Happy) [exp 1,2,3]

Coffee Lid (Happy) [exp 2,3,4,5]

Concrete (Happy) [exp 1]

Drain (Sad) [exp 1]

Drawer (Afraid) [exp 1,2,3]


Guitar (Sad) [exp 4,5]


Hamper (Happy) [exp 4,5]


Kayak (Angry) [exp 1,2,3]


Laptop Case (Angry) [exp 2,3,4,5]


Outlets (Angry) [exp 1]


Peppers (Afraid) [exp 1]


Pink Purse (Happy) [exp 1,2,3,4,5]


Plastic (Sad) [exp 1]


Plastic Bag (Afraid) [exp 1,2,3,4,5]


Slippers (Angry) [exp 2,3]


Teapot (Afraid) [exp 2,3,4,5]


Tower (Afraid) [exp 2,3,4,5]

Tree (Angry) [exp 1]

Ball [exp 1]

Bicycle [exp 1]

Bottle [exp 1]

Bowl [exp 1]

Chair [exp 1]

Comb [exp 1]

Hat [exp 1]

Lamp [exp 1]

Dice [exp 1]

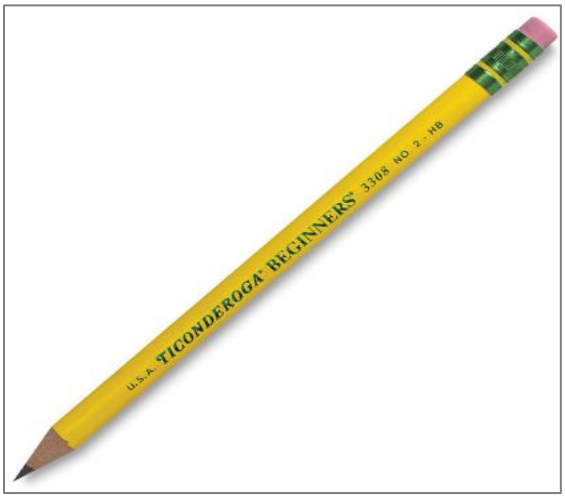
Glasses [exp 1]

Guitar [exp 1]

Hammer [exp 1]

Teapot [exp 1]

Toothbrush [exp 1]



Pencil [exp 1]

Penny [exp 1]

Rock [exp 1]

Spoon [exp 1]

Anemone [exp 1]

Ant [exp 1]

Bear [exp 1]

Bee [exp 1]

Antelope (Front) [exp 2,3]

Antelope (Back) [exp 2,3]

Armadillo (Front) [exp 2,3]

Armadillo (Back) [exp 2,3,4,5]

Camel (Front) [exp 2,3,4,5]

Camel (Back) [exp 2,3]

Bird [exp 1]

Bunny [exp 1]

Butterfly [exp 1]

Cat [exp 1]

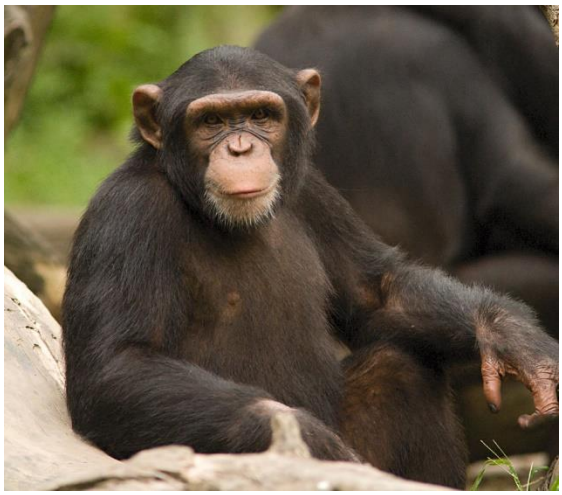
Clam [exp 1]

Cow [exp 1]

Capybara (Front) [exp 2,3]

Capybara (Back) [exp 2,3,4,5]

Caterpillar [exp 1]

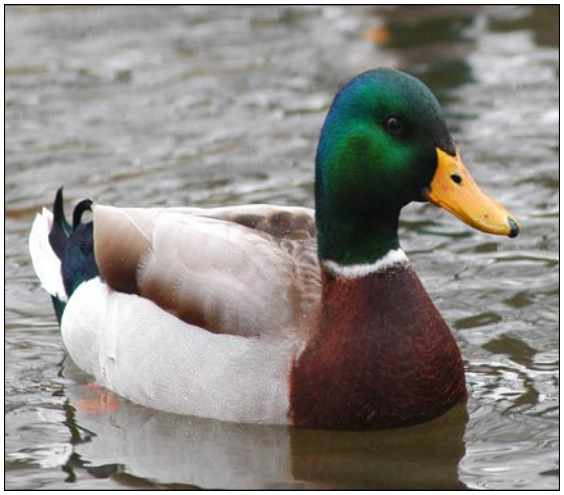


Chimpanzee [exp 1]

Echidna (Front) [exp 2,3]

Echidna (Back) [exp 2,3,4,5]

Dog [exp 1]



Duck [exp 1]

Earthworm [exp 1]

Elephant [exp 1]

Fish [exp 1]

Flatworm [exp 1]

Frog [exp 1]

Horse [exp 1]

Iguana (Back) [exp ,4,5]

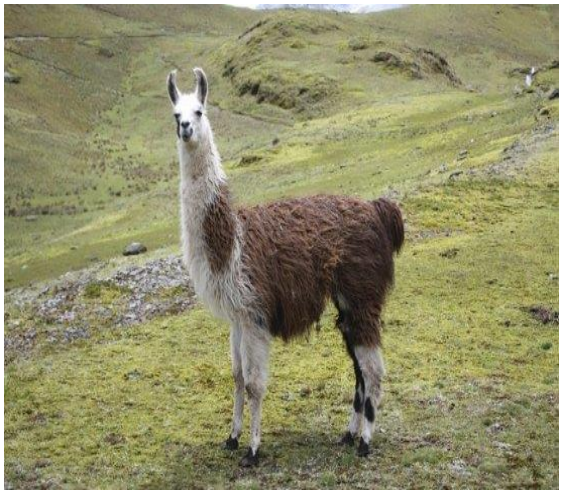
Jellyfish [exp 1]

Gorilla (Front) [exp 2,3]

Gorilla (Back) [exp 2,3]

Hedgehog (Front) [exp 2,3,4,5]

Hedgehog (Back) [exp 2,3]



Llama (Front) [exp 2,3]

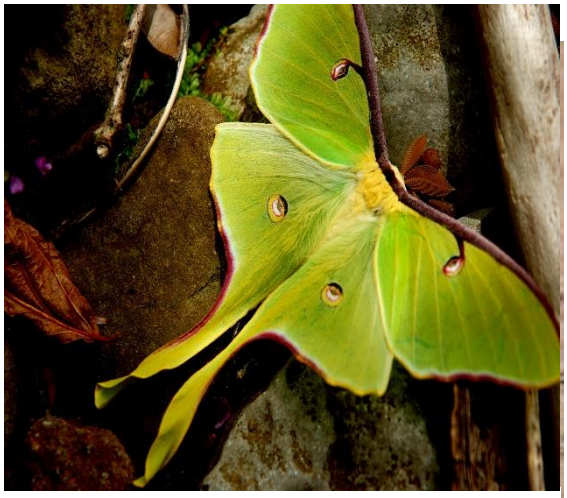
Llama (Back) [exp 2,3]

Lion (Front) [exp 2,3,4,5]

Lion (Back) [exp 2,3]

Lizard [exp 1]

Meerkat (Front) [exp 2,3]



Moth [exp 1]

Meerkat (Back) [exp 2,3]

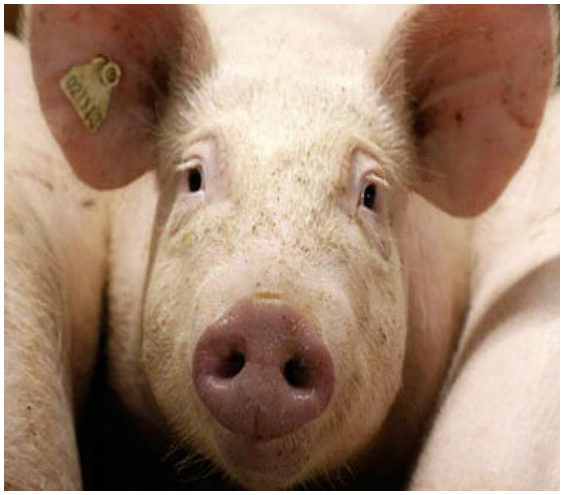
Mouse [exp 1]

Octopus [exp 1]

Okapi (front) [exp 2,3]

Okapi (Back) [exp 2,3]

Panda [exp 1]



Pig [exp 1]

Pangolin (Front)

Pangolin (Back)

Pill Bug [exp 1]

Ray [exp 1]

Raccoon (Front) [exp 2,3]

Raccoon (Back) [exp 2,3,4,5]

Seahorse [exp 1]

Snail [exp 1]

Seagull (Front) [exp 2,3,4,5]

Seagull (Back) [exp 2,3]

Scorpion [exp 1]

Sea Slug [exp 1]

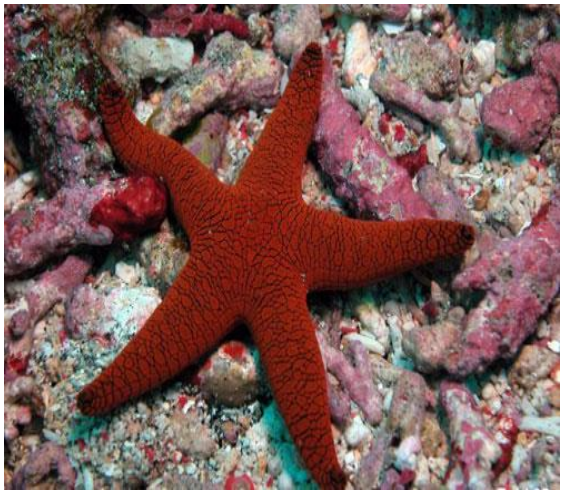
Tapir (Front) [exp 2,3]

Tapir (Back) [exp 2,3,4,5]

Sloth (Front) [exp 2,3, 4,5]

Sloth (Back) [exp 2,3]

Squid [exp 1]



Starfish [exp 1]

Turtle (Front) [exp 2,3]

Turtle (Back) [exp 2,3,4,5]

Wombat (Front) [exp 2,3,4,5]

Wombat (Back) [exp 2,3]

Image Pre-test ("Rate the following adjectives as they apply to the image below"; Scale range from 1 "Not at all" to 4 "Very much")

		Happy	Sad	Angry	Afraid	1.5 * SD highest unaltered rating	Upper bound (highest unaltered rating - 1.5 * SD highest unaltered rating)
Alarm Clock*	Unaltered	1.11	**3.00**	1.16	1.74	1.77	1.23
	Scrambled	1.12	1.18	1.19	1.08		
Backpack	Unaltered	1.04	1.30	**3.26**	1.21	1.75	1.50
	Scrambled	1.27	1.47	1.14	1.27		
Bathtub	Unaltered	1.55	**2.55**	1.83	2.40	0.95	1.60
	Scrambled	1.47	1.57	1.40	1.43		
BBQ	Unaltered	1.04	1.78	**3.28**	1.48	1.55	1.72
	Scrambled	1.24	1.10	1.08	1.10		
Bike Chair*	Unaltered	1.15	1.52	1.48	**2.70**	0.56	2.14
	Scrambled	1.13	1.27	1.13	1.27	0.12	
Brown Purse	Unaltered	1.50	**3.32**	2.11	2.17	1.26	2.06
	Scrambled	1.77	1.85	1.66	1.64		
Cake	Unaltered	1.38	2.00	**3.30**	1.61	1.43	1.87
	Scrambled	1.83	1.68	1.74	1.47		
Camera*	Unaltered	1.66	2.55	1.77	**2.72**	0.92	1.80
	Scrambled	1.36	1.42	1.25	1.43		
Can Lid	Unaltered	1.00	**3.21**	1.32	2.11	1.25	1.96
	Scrambled	1.00	1.35	1.35	1.31		
Car*	Unaltered	1.49	1.89	2.28	**3.06**	1.41	1.65
	Scrambled	1.32	1.28	1.47	1.43		
Chain	Unaltered	**3.21**	1.45	1.36	1.40	1.36	1.85
	Scrambled	1.53	1.64	1.74	1.53		
Chair	Unaltered	**2.83**	1.66	1.57	1.47	1.18	1.65
	Scrambled	1.42	1.58	1.40	1.45		
Chairs	Unaltered	**3.57**	1.23	1.40	1.30	1.07	2.50
	Scrambled	1.51	1.38	1.28	1.38		
Clock Dials*	Unaltered	1.34	**2.74**	1.13	2.06	1.19	1.55
	Scrambled	1.31	1.14	1.00	1.13		
Coffee	Unaltered	**3.60**	1.35	1.57	1.40	0.92	2.68
	Scrambled	1.57	1.49	1.36	1.43		
Coffee Lid	Unaltered	**3.19**	1.02	1.06	1.13	1.35	1.84
	Scrambled	1.24	1.10	1.06	1.20		

Image Pre-test ("Rate the following adjectives as they apply to the image below"; Scale range from 1 "Not at all" to 4 "Very much")

		Happy	Sad	Angry	Afraid	1.5 * SD highest unaltered rating	Upper bound (highest unaltered rating - 1.5 * SD unaltered rating)
Concrete*	Unaltered	**3.21**	1.74	1.64	1.77	1.36	1.85
	Scrambled	1.58	1.72	1.64	1.72		
Drain	Unaltered	1.43	**3.00**	1.74	2.45	1.17	1.83
	Scrambled	1.42	1.60	1.58	1.58		
Drawer	Unaltered	1.38	2.34	1.94	**2.94**	1.30	1.63
	Scrambled	1.34	1.43	1.28	1.42		
Guitar*	Unaltered	1.36	**2.70**	1.40	2.02	1.29	1.42
	Scrambled	1.29	1.08	1.12	1.08		
Hamper	Unaltered	**3.17**	1.02	1.04	1.04	1.57	1.60
	Scrambled	1.14	1.24	1.00	1.08		
Kayak	Unaltered	1.31	1.96	**3.30**	1.87	1.29	2.01
	Scrambled	1.89	1.83	1.60	1.72		
Laptop Case	Unaltered	1.30	1.98	**2.81**	1.28	1.24	1.57
	Scrambled	1.37	1.10	1.04	1.02		
Outlets	Unaltered	1.47	2.04	**3.00**	2.02	1.43	1.57
	Scrambled	1.47	1.38	1.49	1.49		
Peppers	Unaltered	1.49	2.09	2.32	**2.94**	1.30	1.63
	Scrambled	1.51	1.42	1.53	1.49		
Pink Purse	Unaltered	**3.43**	1.49	1.43	1.45	1.24	2.18
	Scrambled	1.58	1.53	1.51	1.45		
Plastic	Unaltered	1.60	**3.15**	1.89	1.91	1.36	1.79
	Scrambled	1.32	1.58	1.60	1.49		
Plastic Bag	Unaltered	1.49	2.57	1.94	**3.19**	1.45	1.74
	Scrambled	1.49	1.72	1.53	1.47		
Slippers	Unaltered	1.49	1.64	**3.26**	1.77	1.23	2.03
	Scrambled	1.92	1.32	1.36	1.40		
Teapot	Unaltered	1.79	2.26	1.85	**3.06**	1.23	1.84
	Scrambled	1.51	1.42	1.34	1.26		
Tower	Unaltered	1.11	1.72	1.68	**2.55**	0.31	2.25
	Scrambled	1.35	1.22	1.12	1.33		
Tree*	Unaltered	1.55	2.21	**3.02**	1.91	1.23	1.79
	Scrambled	1.62	1.64	1.53	1.53		

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